THE WESTERN AUSTRALIAN

NATURALIST

Vol. 30 No. 3 June 30, 2016

Photos: Jolanda Keeble.

This issue is dedicated to GREG KEIGHERY in recognition of his remarkable achievement in publishing over 50 papers in this journal. Greg's first paper appeared in 1974 and his publishing record now spans 42 years.

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Print Post Approved
PP 6358 23/00015
ISSN 0726 9609

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Typeset and printed in Western Australia

THE WESTERN AUSTRALIAN
NATURALIST

Vol. 30 30th June 2016 No. 3

BOBTAIL SKINK (*TILIQUA RUGOSA*) OBSERVATIONS ON THE DARLING SCARP, PERTH, WESTERN AUSTRALIA, 1985–2015

by MICHAEL BROOKER

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'*...at the Rump, instead of the Tail there, they had a Stump of a Tail, which appeared like another Head; but not really such, being without Mouth or Eyes: Yet this Creature seem'd by this Means to have a Head at each End;...the Legs also seem'd all 4 of them to be Fore-legs, being all alike in Shape and Length, and seeming by the Joints and Bending to be made as if they were to go indifferently either Head or Tail foremost. They were speckled black and yellow like toads, and had Scales or Knobs on their Backs like those of Crocodiles, plated on to the Skin, or stuck into it, as part of the Skin. They are very slow in Motion; and when a Man comes nigh them they will stand still and hiss, not endeavouring to get away.*' (Dampier 1703).

ABSTRACT

Thirty-one years of observations are presented on the Bobtail skink *Tiliqua rugosa*, a large, long-lived, viviparous, omnivorous skink on a section of the Darling Scarp, east of Perth, Western Australia. Details are given on their dimensions, injuries, tick load, density and other aspects of their biology. The area is very fire-prone with six major wildfires impacting it during the course of this study. The Bobtail population did not appear to be greatly affected by the first three fires but numbers declined steeply and have remained low since a widespread fire on 6 February 1994. As well as the effect of this fire, the possible roles of rainfall, tick load and the infectious disease URTI, are discussed. These results are compared with long-term data obtained from the same area for some avian species.

INTRODUCTION

Bobtail skinks *Tiliqua rugosa* have a widespread distribution across southern mainland Australia (Cogger 2014) and, despite being one of the most conspicuous components of the herpetofauna around Perth, there have been few published studies of the population ecology in Western Australia (see references in Storr *et al.* 1999, p 274). In the aftermath of a hot wildfire in January 1985 on a 120 ha area of the Darling Scarp at Gooseberry Hill, a number of killed and injured Bobtails were found (Rowley and Brooker 1987). From this date, local populations of this species and the Western Bluetongue lizard *T. occipitalis*, have been monitored. Both are slow-moving skinks which forage and shelter on or near the surface of the ground and so are vulnerable to the effects of wildfire, both to the individual and its environment. During the course of these observations, there were a further five large wildfires on the study area.

STUDY AREA

The observations were made on part or all of the 120 ha study area established to research the biology of the Splendid Fairy-wren *Malurus splendens* (Rowley 1981). The study area, described by Brooker (2001a), extends from the Darling Plateau to the Helena River with steep north-facing slopes, deeply incised gullies and numerous rock outcrops. The vegetation consists of heathland with a variable overstorey of Marri *Corymbia calophylla* and Wandoo *Eucalyptus wandoo*. The area is very fire-prone with some parts burnt by at least 25 fires since 1958, of which six burnt significant portions during the course of these observations. The two most recent fires were on 21 December 2001, which burnt 60% of the study area; and 8 March 2007, which was a hot fire and burnt 90% of the area. Details of the earlier 23 fires are given in Brooker 2001a. Prior to the 1985 fire, there had not been a fire of similar scale since 1972, although in 1977, 60% of the area was burnt.

METHODS

The main field activities on the study area involved censusing selected populations of birds, searching for their nests during the breeding season, and, in some years, undertaking east-west vegetation transects on a 100m grid — a full list of relevant publications can be found in Brooker (2001a). Bobtails were detected opportunistically during this field work, either by sight or occasionally by sound in dense vegetation. During the nine years from February 1985, the protocol for each encounter was to record location, time and date. For most animals found prior to 1994, I also measured body weight (to nearest 5gm with 1000gm Pesola scales), total body length (to nearest 0.5cm

with a steel tape) which was adjusted if the tail was damaged (slight damage, add 0.5cm, moderate, add 1.0cm, major, add 1.5cm); counted the number of ticks and noted their locations; and from 1985 to 1997 and 2011–2015 counted three recognizable tick forms separately, i.e. Brown [BR], Large White [LW] and Small Grey or White [SGW], which categories probably refer to adult males, adult females and larvae/nymphs respectively (M. Bull pers. comm.); and described any other features or items of interest such injuries, sloughing, or pairing. Snout-vent measurements and sexing by cloacal examination were attempted, but were not persisted with because they were both time-consuming and liable to be messy. For encounters between 1994 and 2010, only date, location and size (small, medium or large) were recorded. From 2013 to 2015, observations were also made in my suburban garden 1.5km south-west of the wren study area in habitat similar to the southern section of the area. Bobtails were measured and released where found.

All observations were made by me except for 38 animals processed by colleagues between 1985 and 1987, which were excluded from the density estimates. Records were made in all months but were concentrated in August–January during the first 23 years and thereafter confined to September–December. The underlying field protocol (i.e. searching for birds and their nests) remained constant throughout the study period and no special effort was made to locate Bobtails. The scope of the field work declined over time.

The area monitored varied from 120 ha in 1985–1994, to 80 ha during the 1995–2003 period and 20ha thereafter (Figure 1). As the estimated density for 1985–1994 on the 20ha area (3.75 per ha) was similar to that recorded on the other 100 ha (3.43 per ha), and the estimated density for the 1995–2003 period on the 20 ha area (0.85 per ha) was similar to that recorded on the other 60 ha (0.50 per ha), the whole area searched was used to estimate density.

As well as the reduction over time in the area searched, there was a comparable reduction in the time spent on avian field work, which varied from over 400 hours in 1985 to as little as 40 hours in 2007 and 2009. To estimate search effort, the number of hours spent on the study area for each month in each year was calculated from field note books.

RESULTS

Data were obtained from 521 Bobtail sightings on the Gooseberry Hill study area (Figure 1). Of these, 30 had markings or injuries which made them individually identifiable, and four (13.3%) were re-sighted 1, 3, 22, and 27 months later, at distances of 90, 150, 55 and 95m

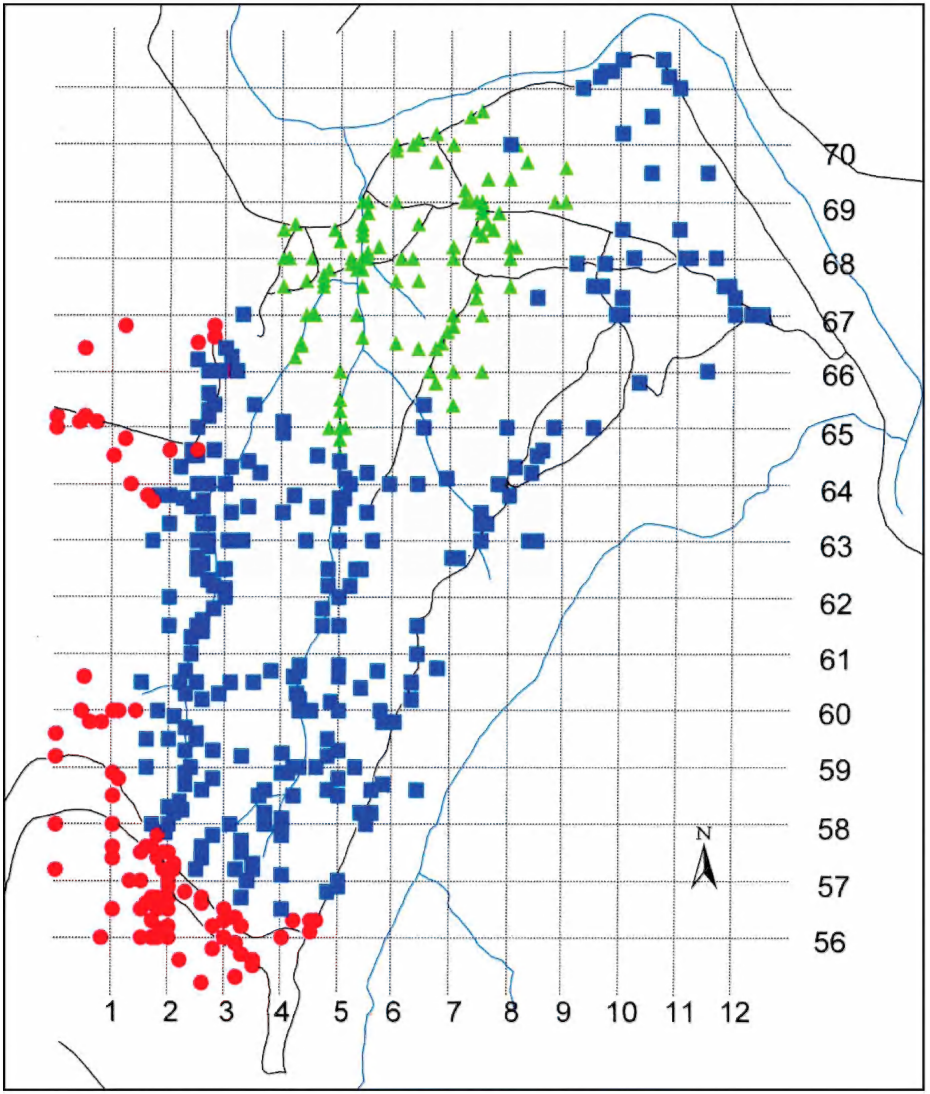

Figure 1. The locations of Bobtail sightings on the Gooseberry Hill study area. Streams shown in blue (Helena River on north boundary), roads in black (Zig Zag Road on south-west corner). Triangles = area searched 1985–2015; squares = searched 1985–2003; circles = searched 1985–1994. Grid 100m.

respectively from their initial capture sites. By extrapolation, it can be estimated that about 442 different Bobtails may have been found during the study, with about 70 of them resighted at least once, nine twice and one thrice.

Only two Western Bluetongue lizards were seen (one in December 1994, which measured 38cm and one in January 1996 measuring 40cm) and, as these two sightings were within 200m of each other, they could have been of the same animal. Bamford (1980) also found low numbers of Bluetongues relative to Bobtails on his Perth site.

Distribution and density

There was at least one record for all except two of the 120 one-hectare squares on the pre-1995 Gooseberry Hill study area (Figure 1) and the distribution of sightings mirrored those areas where observers were most often engaged searching for wren nests (see Figure 21 of Brooker 2001b) and conducting other avian-related activities; i.e. along roads, paths, and stream lines. For this reason, it was not possible to measure actual Bobtail density, with the possible exception of the 4 ha lateritic community on the southern end of the area where search coverage was fairly uniform in some years. On this area, 43 Bobtails were recorded between 1985 and 1990 which, assuming no mortality and 13% recapture, equates to a density of about 10 per ha.

The number observed per month, corrected for time I spent in the field, was low in winter months, with a peak in October (Figure 2). The annual estimates of density, using sightings made September–December (the only period with continuous records) are given in Figure 3, together with the timing and extent of the six wildfires. It shows that

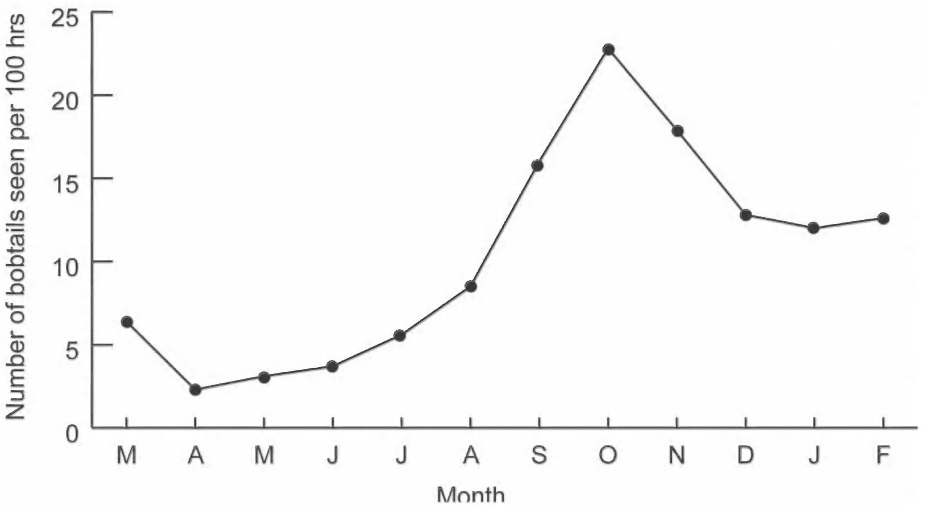

Figure 2. Number of Bobtails seen per 100 hours of searching per month.

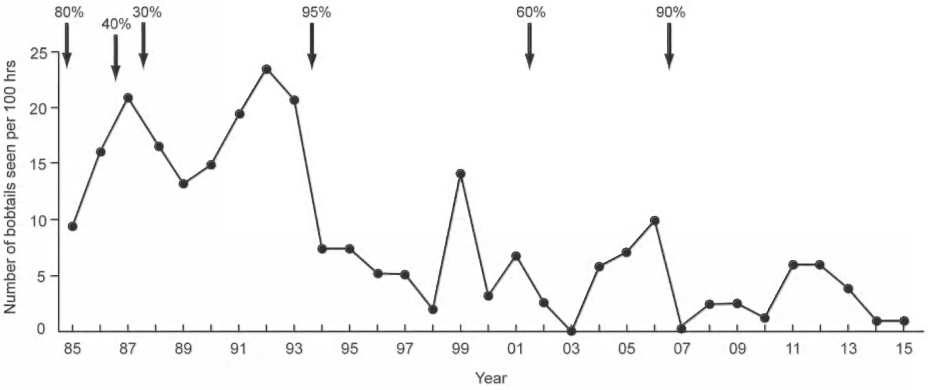

Figure 3. Annual density of Bobtails (number seen per 100 hours) on 20 ha searched from September to December, 1985–2015. Arrows from above show the timing and percentage of the entire 120 ha study area that was burnt by 6 wildfires. The fires of 1987 and 1988 did not impinge on the 20ha area.

densities for the last 22 years (4.7 ± 3.4; 0–14.1; n = 22) were only a quarter of those recorded in the late 1980s and early 1990s (17.2 ± 4.1; 9.4–23.5; n = 9). Further confirmation of the lower densities since 1994 was obtained during vegetation transects each totalling about 10 km (Brooker and Hussey 2001) undertaken by me in August, September, October and December 1994, October–December 1995 and October–November 2007. The six transects yielded just 2, 2, 1, 0, 3 and 0 Bobtails respectively at times of year when they should have been active.

The data for 1985–1993 indicated a north-south density gradient across the study area. Within four 30 ha sections, from adjacent the Helena River (20 m asl) in the north to near the top of the scarp in the south (210 m asl), the relative numbers of Bobtails per ha were 2.1, 2.8, 3.7 and 4.3. This assumes that the four 30 ha sections were searched at the same intensity, which was probably true during this period.

Measurements

The mean body weight of 410 animals was 414 ± 112g (range 115–680) and the length (adjusted for tail damage) of the same animals was 33.3 ± 3.4cm (range 20.0–39.5) (Table 1). As this sample would be expected to include 13% re-captures, these averages for weight and length may be inflated as older individuals were more likely to be recaptured since mortality may be higher in younger (smaller) animals (Bull 1995). Snout-vent length (SVL) was measured on 24 animals and was found to average 80.3 ± 3.4% of body length. This figure approximates that given by Cogger (2014) of 75–80%, and Bamford (1980) of 78%.

Table 1. Body mass and length according to season (Autumn = March – May; Winter = June – August; Spring = September – November; Summer = December – February).

Season	Body Mass (g) Mean ± SD	Range	n	Body Length (cm) Mean ± SD	Range	n
Autumn	373 ± 97	165 – 530	16	32.7 ± 3.3	26.0 – 36.5	16
Winter	394 ± 108	115 – 600	48	33.4 ± 3.9	20.0 – 39.0	48
Spring	417 ± 110	140 – 600	249	33.2 ± 3.4	20.5 – 39.5	249
Summer	425 ± 119	150 – 680	97	33.7 ± 3.1	25.0 – 39.5	97
All	414 ± 112	115 – 680	410	33.3 ± 3.4	20.0 – 39.5	410

Table 2. Body mass and length of 291 Bobtails measured between September and December, 1985 – 1993.

Year	Body Mass (g) Mean ± SD	Range	Body Length (cm) Mean ± SD	Range	n
1985	438 ± 98	186 – 570	33.6 ± 2.9	24.0 – 37.0	35
1986	442 ± 81	195 – 565	34.0 ± 2.4	26.0 – 37.5	46
1987	416 ± 117	143 – 570	32.8 ± 3.8	20.5 – 38.0	67
1988	364 ± 128	160 – 675	32.1 ± 3.3	25.5 – 38.0	33
1989	380 ± 131	140 – 560	32.9 ± 4.4	23.5 – 37.5	17
1990	415 ± 118	220 – 555	33.2 ± 3.5	27.5 – 38.5	17
1991	415 ± 106	160 – 550	33.4 ± 3.2	25.0 – 37.0	28
1992	412 ± 113	175 – 640	33.4 ± 3.4	25.5 – 39.5	25
1993	455 ± 87	225 – 600	34.2 ± 2.8	26.0 – 38.5	23
All years	417 ± 112	140 – 675	33.3 ± 3.4	20.5 – 39.5	291

Variation between seasons in weight and length as shown in Table 1 follow that expected from the life history of Bobtails (see Discussion). Table 2 gives mean weight and length for 291 Bobtails measured in September–December over nine years from 1985. The between year differences were significant for both weight ($F=1.98$, df. 8,282, $p < 0.05$) and length ($F=11.4$, df. 8,282, $p < 0.001$).

The head length and width data, either alone or as indices of body length and weight, failed to produce any bimodal distributions which could have been used to sex animals. A similiar conclusion was reached by Bamford (1980) on a much larger data set.

Ticks

A full set of tick data was obtained from 393 Bobtails captured prior to 1994. The ticks were most likely the three-host ixodid tick *Amblyomma albolimbatum* (M. Bull pers. comm.) which has a distribution from the south-west of Western

Australian to the Eyre Peninsula in South Australia (Andrews and Bull 1982). The three forms I recognised were Brown (BR), Large White (LW) and Small Grey or White (SGW), which probably refer to adult males (which do not engorge), adult females and larvae/nymphs (which do engorge) respectively (M. Bull pers. comm.). No ticks were removed during the study.

The number of ticks per Bobtail varied from 0 to 40 (median = 8, mean = 8.6, n = 393). Only 14 were tick-free and 12 of these were found in June–September. The maximum number of BRs on one animal was 36 (in October); for LWs, 8 (in January); for SGWs, 10 (in December). Some BRs were present through the year, with peak numbers from October to December (Figure 4). Large Whites (LWs) were present only in October–February. The proportions of Bobtails with one or more LWs was 5.0% in October, 29.2% in November, 44.2% in December, 48.1% in January and 15.4% in February. SGWs were observed in August through to March with peak numbers in February.

The total number of ticks and number of BRs on a Bobtail were positively related to body weight (Figure 5) and length, whereas the numbers of LWs and SGWs were not influenced by the size of the Bobtail.

Using spring/summer (September–February) data, there were significant between year differences in the total number of ticks and the number of BRs (ANOVAs with square root (n+0.5) transformations; for total ticks $F_{8,295} = 6.59$ ***, for BRs $F_{8,295} = 4.99$ ***). Highest numbers of

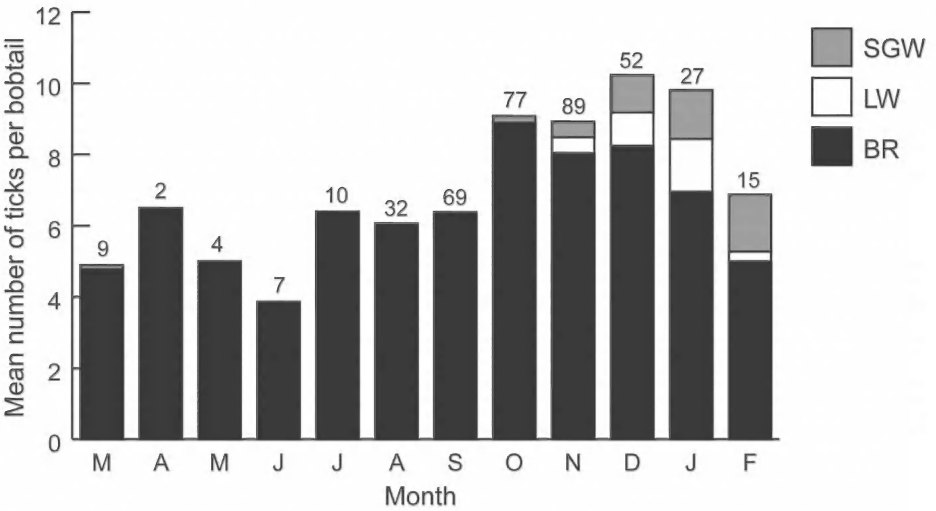

Figure 4. Mean number of ticks per Bobtail by month. BR = adult males, LW = adult females, SGW = larvae/nymphs. (numbers indicate number of Bobtails sampled)

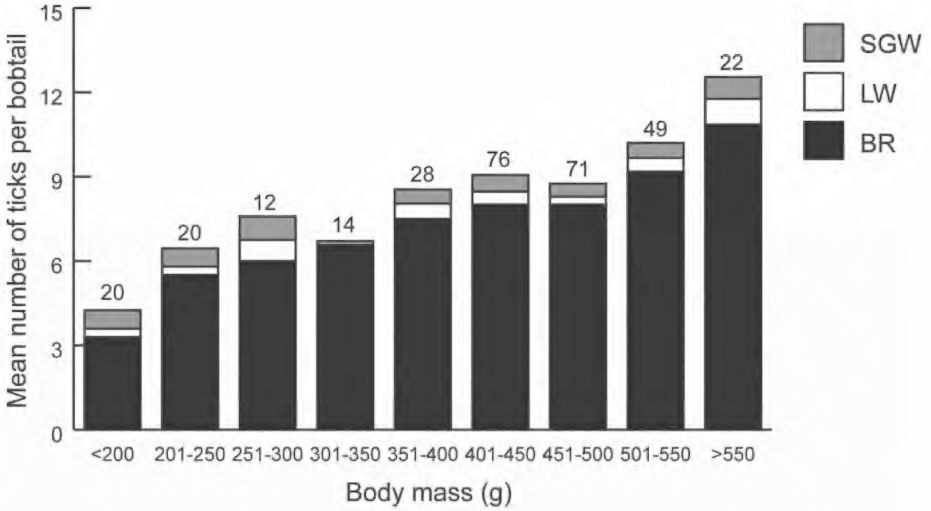

Figure 5. Mean number of ticks per Bobtail according to body weight. BR = adult males, LW = adult females, SGW = larvae/nymphs. (numbers indicate number of Bobtails sampled)

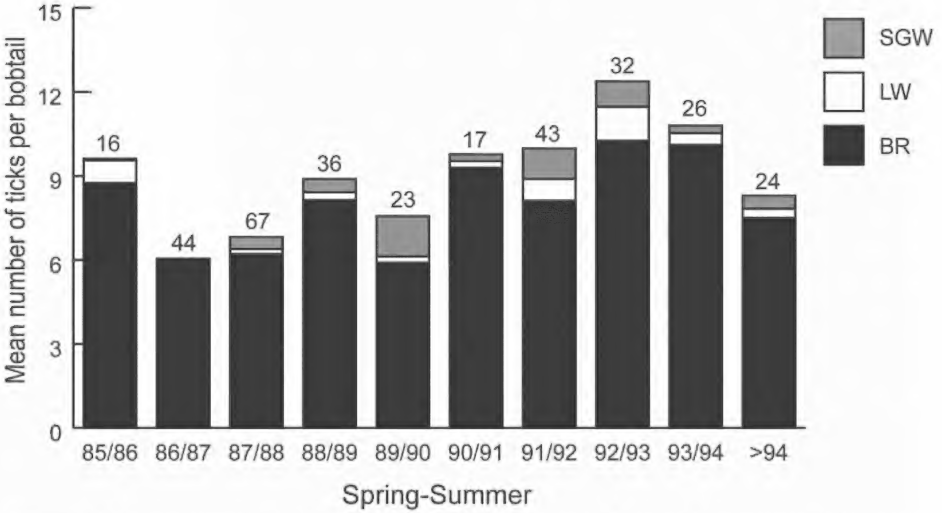

Figure 6. Mean number of ticks per Bobtail recorded in spring-summer by year. BR = adult males, LW = adult females, SGW = larvae/nymphs.

ticks were found in the 1992–1993 and 1993–1994 seasons (Figure 6). In the 1992–1993 season, 50% of animals seen during spring-summer had one or more LWs compared with 20.5% for all records. The mean number of ticks recorded on 13

animals found in September–December since 2010 was 4.1 ± 2.9 which was significantly less than for 286 animals (8.6 ± 5.0) for the same months prior to 1994 (t test, $p<0.001$). Only one of the Bobtails found in 2011–2015 had LW ticks (December 2015). For the small sample found in the Gooseberry Hill garden since 2012 (n = 7), the mean was even lower (1.4 ± 1.1).

There were four common points of attachment for the ticks: i.e. around and in ear canals, on the back of the neck, around the bases of the forelegs and elsewhere on the body (Table 3). BRs showed a strong preference for ears while LWs were mostly found on the neck, under the forelegs and on the body. The majority of SGWs were on the body.

Injuries and Mortality

The most common injuries observed were to the feet and tail. Seventy-four of 420 animals (17.6 %) were missing one or more toes with eight of these having one leg reduced to a stump and one with two stumpy legs (Table 3). Twenty-four (32.4%) had one toe injured, 25 (33.8%) had 2–5 injured toes, 16 (21.6%) had 6–10, 5 (6.8%) had 11–15, and 4 (5.4%) had >15 toes injured. Ten had injured toes on all four feet. None had two injured forefeet and uninjured rear feet. Injuries were more frequently observed on the rear feet than on the forefeet (91:40, $\chi^2_1 = 19.8$, $p < 0.001$). For animals with two injured feet, there was no tendency for them to be on the same side of the body but they were more likely to be the two rear feet (n = 11) than one rear and one forefoot (n = 4) although this difference was not significent ($\chi^2_1 = 3.27$, $p > 0.05$). For animals missing just two toes per foot, the inner and outer toes (n = 22) were more likely to be damaged than the central three (n = 17), ($\chi^2_1 = 4.38$, $p < 0.05$).

Sixty-four of the animals with toe or foot damage had both body weight and length data. The seven with one or two stumps were average in weight

Table 3. Distribution of ticks (BR = brown, LW = large white, SGW = small grey or white) on 393 Bobtails according to location (other = eye, top of head, tail)

Site	BR		LW		SGW		Total	
	n	%	n	%	n	%	n	%
Ears	1750	68.0	17	12.2	26	14.0	1793	55.9
Lips	30	1.0	0	0	3	1.6	33	1.0
Neck	214	7.4	30	21.6	15	8.1	259	8.1
Leg	224	7.8	40	28.8	20	10.7	284	8.9
Body	660	22.9	51	26.7	115	61.8	826	25.8
Other	2	0.1	1	0.7	7	3.8	10	0.3
Total	2880		139		186		3205	

Table 4. Number of injured toes among 74 Bobtails with at least one injured toe.

Foot	Number of injured toes 0	1	2	3	4	5	Stump	% toes injured
Left fore	54	5	4	4	3	3	1	15.4
Right fore	54	7	3	2	3	3	2	15.1
Left rear	30	14	4	9	7	7	3	34.3
Right rear	27	12	14	6	2	9	4	35.4

(416 ± 29 g) but shorter (32.3 ± 2.2cm) than average in length. The overall averages of body weight and length for the other 47 animals were greater than those of the population as a whole (body weight 458 ± 54g versus 414 ± 112; length 34.4cm versus 33.3 ± 3.4cm). There were no identifiable relationships between weight or length either with the number of injured feet per animal or the total number of injured toes per animal. The highest mean body weights and lengths were for groups at either end of the damage spectrum; i.e. the group with one injured foot or only one damaged toe; the group with four injured feet or >10 damaged toes.

An obvious injury to the end of the tail was recorded in 58 Bobtails (15.5%, n=375) and 25 of these also had foot damage. The number of animals with dual damage (43.1%) was significantly in excess of the number expected by chance ($\chi^2_1 = 33.7$, $p < 0.001$). For animals with one or both hind feet damaged, the mean number of toes missing was 4.9 ± 3.5 for animals which also have tail damage versus 3.5 ± 2.5 toes for those with undamaged tails.

Eight of the 13 animals with severe wounds were found in vicinity of roads on the northern and southern sides of the area where they would have been more likely to encounter people, dogs, cats and vehicles. The frequency of Bobtails with tail injuries was much higher in the 10 ha north of the southern road than elsewhere (25.4%, n = 59 versus 12.4%, n = 355). The gradient immediately north this road is steep (see bottom left hand corner of Figure 2 in Brooker 2001a), so perhaps Bobtails that had been injured on the road had escaped downhill and chosen not to return. The proportion of animals with toe or foot injuries did not vary across the area.

A few Bobtails (n=11) had extensive damage to the dorsal scales on their heads and bodies. These were large (perhaps old) individuals with an average length of 35.3 cm, being 2 cm longer than the population mean of 33.3cm. Two others had healed puncture wounds on a limb.

Overall, around 26% of Bobtails had an injury of some kind and 14% more seriously so (e.g. more than four toes missing, moderate

to severe tail or body damage) but most appeared to be coping with their injuries as judged by the recapture of some. The cause of most injuries was unknown, although the stumpy legs were probably from walking in hot ash (see also Bamford 1980 p16). From a fire adjacent to the study area on 14 April 1988, a victim with scorch damage to a hind leg and tail was seen alive and walking on 7 May 1988.

Casualties on local roads were heaviest in September and October when 73% of deaths (n=21) were recorded. Only a handful of burnt dead animals were found after fire — one after the 1985 fire and three each after the 1988 and the 1994 fires. That none were seen after the 2000 and 2007 fires is consistent with low densities at these times (Figure 3). Recorded deaths other than road kills were rare — one in November 1987 which was probably trodden by a horse and single animals in April and July 1993, cause unknown.

In December 1991, a Bobtail was recorded with "eyes half-closed, with puss" and two unusually thin specimens were noted in September of 2002 and 2007. Each of these animals showed symptoms consistent with the infectious disease Upper Respiratory Tract Infection (URTI) (Carol Jackson, pers. comm.).

Other Observations

The two earliest records of sloughing were for two small animals (lengths of 29 and 26cm) on 30 November 1992 and 23 October 1993 respectively. All other records were in December (1), January (6) and February (6). A further 22 animals, which showed evidence of recent completion of skin shedding, such as shiny new scales or some old skin still in the ears, were recorded mainly in December and January (12), with one or two in February to May or November. Two animals found sloughing were tick-free but reinfestation seemed to occur soon after sloughing. Among 104 animals observed December–February, the mean number of ticks per Bobtail on those which appeared to have recently sloughed was 8.0 (n = 22) versus 8.9 ticks per Bobtail for the rest.

There were 28 instances where two Bobtails were found in close proximity (usually within 1 m of each other and/or following), although copulation was recorded only on four occasions — once in October, thrice in November. Most 'pairings' (82%) were during October and November with one each in June, July and September and two in August but none for the other six months. On average, over all years, 21.5% of all animals seen October–November (n = 214) were part of a pair. The frequency of recorded paired animals in the October–November period has not changed over time (1985–1993: 46 pairs among a total 189 found; 1994–2015: 2 pairs in 33 found; $\chi^2_1 = 2.36$ ns).

Ten of 16 records of food items were of flowers, with one each for leaves (Warrine), fruit (blackberries), fungus, a small snail, a tadpole and a dehydrated gecko. At Guildford Cemetery nearby in October 1987, a Bobtail was found with a live 10gm frog *Heleioporus psammophilus* in its mouth. The frog made a noise with each bite and was eventually released, apparently unharmed.

Twins were born in the afternoon of 23 April 2013 in my suburban garden and one of these was resighted at the same place on 21 August 2013. At 4 months of age, it weighed 197 gm and measured 26 cm. Other 'babies' were seen at the same place on 4 April 1996 and 15 April 2011.

Some indication of breeding success was obtained from the proportions of small animals found in September–December. For the first 9 years (1985–1993), 16.2% (n = 302) were less than 30cm long; for 1994–2010, 7.4% (n = 54) were classed as small; and for the five years 2011–2015, 25% (n = 12) were less than 30 cm.

DISCUSSION

Bobtails in the Gooseberry Hill population were smaller than those in a population at Mount Mary, South Australia, where the mean SVL measurement for 7663 Bobtails was 29.0cm with a range of 14.0–33.5 (from Table 2 of Bull 1995) compared with equivalent figure for Gooseberry Hill of 26.6cm, range 16.0–31.6. The respective figures for smallest SVL for individuals showing pairing behaviour were 28cm (Bull 1995) and 26cm (this study). The average SVL for breeding females in South Australia was 31cm (M. Bull pers. comm.), which is equivalent to a length of 38.7cm, a figure exceeded by only four animals in this study.

The mean changes between season in weight (Table 2) and number sighted per month (Figure 2) agree with what is known of this animal's life history (Bull 1995, Haight 2007), in that they are inactive in autumn and winter; give birth to live young in autumn; experience peak activity, mating and weight gain in spring (the highest mean monthly weights were 439 ± 104gm, n = 88 in October and 433 ± 113gm in December, n = 55); and are less active in summer, perhaps due to high diurnal temperatures.

The only estimate of actual density (10 animals per ha) for this population was on a small section on the southern side of the study area and this compares with the maximum density figure (12 per ha) obtained on three habitats at Spectacle Swamp (Bamford 1980). This same area of laterite situated below the top of the scarp also had the highest relative density of Bobtails on the area. Two possible reasons for the higher numbers here were that (a) it is adjacent to houses and their gardens which may be beneficial providers of

food and shelter and (b) Grasstrees *Xanthorrhoea preissii* and the shelter that they provide to Bobtails were more numerous here than elsewhere on the study area (twenty-four out of 50 (48%) plant census sites in laterite contained at least one Grasstree versus 346 of 1056 sites (33%) elsewhere; data from Brooker and Hussey, 2001).

The proportions of Bobtails with toe and tail injuries was higher in the Gooseberry Hill population than that reported by Bamford (1980) for his study area at Spectacle Swamp, on the Swan Coatal Plain, 35km south-west of Gooseberry Hill (15% versus 7.3% toe damage; 15% versus 5.7% tail damage). The fact that toe loss on the rear feet was over twice as frequent as on forefeet may indicate that Bobtails can protect their forelimbs better than their rear limbs. Schoener and Schoener (1980) suggest that this discrepancy indicates that predation is a more important cause of toe loss than intraspecific conflict.

If the fire of January 1985 contributed to a decline in density the following season, numbers soon recovered, and the fires in 1987 and 1988 did not appear to have significant impacts. However, the 1994 fire, despite being similar in intensity, extent and timing to that of 1985, was followed by a major and sustained decline in the number of Bobtails. Sightings went from 20.7 per 100hr in 1993 to 7.4 in 1994. The mean number of sightings per 100 hours for the nine post-fire years (1985–1993) was 17.2 ± 4.1 compared to 4.7 ± 3.4 per 100hr for following 22 years (1994–2015). There were declines in the years after two subsequent fires in 2000 (from 14.1 to 3.2) and 2007 (from 10.4 to 0), but these were based on already low numbers. The 2007 wildfire was the most severe of the three widespread recent fires. It was late in the season (March) and the heat generated caused extensive exfoliation of granite rocks, and many mature Marris and Wandoos were either killed outright or, if still alive, only resprouted from their bases – reactions not observed after any of the other fires.

There were no reliable reports of URTI before 1996 (Haight 2004) but it is possible that URTI had been operating in the local population earlier than this, for I found an animal in December 1991 with symptoms consistent with what was later diagnosed as URTI. Infected animals have been treated, many successfully, at the Kanyana Wildlife Rehabilitation Centre, Perth. The number of patients peaked in 2002 (Haight 2004) and sick animals have continued to be admitted to the Centre each year since (Carol Jackson pers. comm.) If this disease was prevalent in the study area population in 1993, it may have been a contributing factor to the big decline in numbers observed during the following September–December and may still be inhibiting their recovery.

Low rainfall in the three months after the 1994 fire (just 4 mm compared to an average of 73 mm, n = 44) may also have affected the post-fire population. The recovery of the vegetation after the 1994 fire was initially slower than for the previous burns and this could have been due to lower rainfall (Brooker 1998). The mean annual rainfall for the 22 years after the 1994 fire (774 ± 125mm) was lower than mean amount recorded in the previous 22 years (810 ± 125mm) with less on average in summer, autumn and winter but more in spring. While changes in rainfall could have influenced the initial decline and/or the lack of recovery following the 1994 fire, any analysis is confounded by the two subsequent fires.

The tick load of the Gooseberry Hill population can be compared with one in South Australia, where the tick is the congeneric *Amblyomma limbatum*. Using the same August–December period as Bull and Burzacott (1993), mean number (and range) of ticks per animal over 8 years in South Australia was 8.7, 6.8 – 14.1, which is much the same as the equivalent figure over 9 years in this study (9.2, 6.0 –12.1). The mean September–December tick load per animal was highest in the two years prior to the 1994 decline in density and the number of engorging females (LWs) was highest in the 1992–1993 season. The level of tick infestation could have contributed to the 1994 decline as tick exposure had a negative effect on survival in a South Australian population (Jones *et al.*, 2016). However I failed to record tick data for next 17 years after 1994. Numbers of ticks recorded since 2011 were significantly lower than those for the 9 years 1985–1993, suggesting that the low density of Bobtails may have affected tick density.

Detailed breeding and occurrence data for several small resident insectivorous passerine bird species were collected concurrently with the Bobtail study (Brooker 1998, Brooker 2001b, M. Brooker unpubl.). The populations of three other species (Splendid Fairy-wrens, Weebills *Smicrornis brevirostris* and White-browed Scrubwrens *Sericornis frontalis*) were affected to varying degrees by the 1994 and other fires, but did not experience any long-term decline as was seen in the Bobtail. However, three species of thornbills *Acanthiza inornata, A. chrysorrhoa, A. apicalis* and the Scarlet Robin *Petroica boodang* are now much less numerous on the study area than they were in 1985–1993 when Bobtail numbers were at their highest. The reasons for this are not clear but their declines were more gradual than experienced by the Bobtail population and the 1994 fire did not appear to play a pivotal role.

ACKNOWLEDGEMENTS

I would like to thank Michael Bull of the School of Biological

Sciences at Flinders University, who provided information and encouragement during the course of this study. Belinda Cale drew the figures and commented on the manuscript. I am also most grateful to Ruth Haight and Carol Jackson of Kanyana Wildlife Rehabilitation Centre and Bethany Jackson of the School of Veterinary and Life Sciences at Murdoch University who gave me information about the prevalence of Upper Respiratory Tract Infection in Bobtails.

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SILVER GULLS (*CHROICOCEPHALUS NOVAE-HOLLANDIAE*) AS VECTORS FOR INVASIVE OLIVES (*OLEA EUROPAEA* SSP. *EUROPAEA*) ONTO PENGUIN ISLAND, SHOALWATER BAY, ROCKINGHAM

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INTRODUCTION

Gulls are typically opportunistic scavengers. Omnivores with a diverse diet that often includes seeds and fruits, they can be effective dispersers of coastal plants and important vectors for movement of plant material, particularly to offshore Islands (Green 2016; Calvino-Cancela 2011). They have long been known to be effective carriers of weed seed (Gillham 1956) and as such have often been noted as significant vectors of invasive plants onto offshore Islands (Abbot and Black 1980; Morton and Hogg 1989; Green 2016; Calvino-Cancela 2011). Herring Gull (*Larus argentatus*) have been recorded as dispersers of common oats (*Avena sativa*) and Barley (*Hordeum vulgare*) to the Welsh Islands (Gillham 1956) and American Herring Gulls (*L. smithsonianus*) and Ringbilled Gulls (*L. delawarensis*) have been recorded as major vectors for spread of invasive plants mostly broad leaf herbs and grasses onto the Islands of the Great Lakes, Canada (Morton and Hogg 1989). In Australia, Pacific Gulls (*L. pacificus*) have been reported as vectors for spread of two invasive shrubs, Boxthorn (*Lycium ferocissimum*) and Mirror Bush (*Coprosma repens*) between the Bass Strait Islands (Calvino-Cancela 2011).

Dispersal of Olive seed to Penguin Island

The thousands of woody fruits voided from Silver Gulls onto the board walk at Penguin Island in Autumn 2014 (Figure 1) were initially thought to be from the native grape (*Nitraria billardierii*) but once seed was collected, potted up and had germinated it was evident the fruit was actually from Olives. It has been noted that gulls consume Olives where they grow in their native range and Herring Gulls have been documented as being responsible for the spread of viable seeds from orchards on the Croatian mainland to small offshore islands (Spennemann and Allen 2000). This record of a mass dispersal event of Olive seed from mainland WA to one of Perth's offshore islands is of concern given the invasive

Figure 1. Olive seed on the boardwalk at Penguin Island.

nature of the species in southern Australia and the impacts Olives can have on biodiversity (Spennemann and Allen 2000; Crossman 2002).

The impacts of Gulls as vectors for invasive plants onto Perth's offshore islands is compounded by the gregarious nature of these birds and their increasing population densities associated with increasing volumes of human refuse on the mainland. Silver Gulls were not recorded nesting on Penguin Island until the early 1960s and by the 1990s an estimated 3000 pairs of breeding birds were recorded on the Island (Department of Conservation and Land Management 1992). With the colony still expanding, the mass dispersal of Olive seed to Penguin Island by Silver Gulls is one example of the impacts increasing population densities of these birds might have on Perth's offshore islands.

It is only relatively recently that Olives have become established in bushland around Perth and south-west Australia (Hussey *et al.* 2007). Dispersal by birds from plantations and ornamental street trees in the suburbs of Perth appear to be the primary cause. Olives are increasingly used as ornamental amenity trees in newer coastal suburbs in close proximity to the Islands in Shoalwater Islands Marine Park and these plantings are the likely source of seed we observed being dispersed en masse to Penguin Island via Silver Gulls.

Fate of Olive seed dispersed onto Penguin Island

At the same time as Olive seed appeared on the board walk, restoration trials using weld mesh cages to protect planted tube stock and seed from Silver Gulls were being established on Penguin Island. These trials were

a

b

Figure 2. a) Olive seed voided into restoration plots, July 2015 b) Silver Gulls perching on weld mesh cages.

subject to monthly monitoring from March 2015 to December 2015. Throughout the course of the trials large numbers of Silver Gulls were continually perched on the weld mesh cages, voiding Olive seed into our restoration trials and providing an opportunity to observe the fate of Olive seed brought onto the island (Figure 2a & b). While hundreds of seeds were voided over many months only three germinants were observed (Figure 3) and all died within one month of germination. A study on the recruitment dynamics of *Olea europaea* (Rey and Alcantara 2000) found that germination was very low in sites with little or no shrub cover and that the effects of water stress was the main determinant of seedling survival, with nearly 100% mortality in some years. The sites

Figure 3. Olive seed germinating in restoration trials, August 2015.

we were observing were open with little vegetation cover possibly accounting for the very few germinants observed. In addition our observations were made over the winter of 2015 one of the driest on record for the Perth metropolitan area (Commonwealth of Australia 2016). This probably accounted for lack of seedling survival. In wetter years seedlings may possibly survive and go on to establish mature plants. The use of Olives as street trees and in amenity plantings should be reconsidered given their invasive nature and the increasing population densities of Silver Gulls, a major vector for spread.

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SUBURBAN OCCURRENCE OF BIRDS: A MICROGEOGRAPHIC PERSPECTIVE BASED ON COMPARISON OF TWO SITES IN INNER SUBURBS OF PERTH

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ABSTRACT

We report the results of 4 years of consecutive weekly recording of bird species at our places of residence in the suburbs of West Leederville and North Perth. Although < 2 km apart, differences between the two sites in the frequency of occurrence of some bird species were found during the period 2011–14 and during each year. Some species also showed irregular monthly variation in frequency of occurrence at the same site. Carnaby's Cockatoo, Galah, Little Corella, Black-faced Cuckoo-shrike and Grey-breasted White-eye exhibited marked seasonal variation. The method of recording used by us is simple, accurate and convenient. It is described in detail to allow others to apply it to their places of residence and thus build up a more comprehensive picture of the extent of stability and change in the bird species occurring in the gardens of suburban Perth.

INTRODUCTION

'Sense of place' is an ill-defined characteristic that arises from prolonged residence and acquaintance with the local environment (Seddon 1972). Somewhat mystical, it implicitly alludes to the concept of *genius loci* prevalent during the Roman empire, as well as including the concept of spiritual empathy (Pizzey 2000). More scientifically, sense of place embraces an understanding of the linkages between a complex array of factors, particularly climate, geological setting, soils, vegetation (native and exotic), and biota. To humans, birds, trees and wildflowers are the most familiar components of biodiversity. Although suburban gardens usually lack their original vegetation (which was cleared to create the roads, railways, residential and industrial features of the suburban landscape), many species of native birds still reside in

or visit the gardens and parks of metropolitan Perth (Van Delft 1997).

The suburbs of Australian cities are much simplified ecosystems (Keast 1995, Loyn and Menkhorst 2011, Recher 2010, Tait *et al.* 2005). In Western Australia the greatest number of local extinctions of bird species has occurred in metropolitan Perth (Abbott 1997). Species unable to survive the changes to the landscape as it was when first settled by Europeans became locally extinct. Several species that were probably rare at that time have become more common to the extent that the new habitats provided by settlement suited them. The remainder of the species are resilient and adaptable and still occur frequently (Brooker and Brooker 1998, Grayson *et al.* 2007, Abbott 2009).

Birdwatchers in suburban Perth have often reported to us that an unusual species has been seen at their place of residence. However, when questioned about the date of occurrence, nothing definite can be recalled. Consequently, the record is unavailable to those interested in bird distribution in suburban Perth. Evidently most birdwatchers consider it uninteresting to keep records of bird species occurring in private gardens. In addition, if records are kept, little thought is given to the optimal unit (week, month or a running list to which new species are added), how these records could be analysed, and whether they merit publication.

Previous site-based surveys of birds in suburban Perth commenced formally in 1996 when Birds Australia (Western Australia) issued a recording sheet (*Western Australian Bird Notes* March 1996 No. 77). This comprised a list of 25 species, with space provided for additional species to be listed. Sufficient space on this form enabled species seen or heard on up to 5 days in a month at the surveyed site to be recorded. Inspection of many completed forms, held in the archive of BirdLife Australia (Western Australia) in Floreat, indicates that most forms list species present on only one day of each week per month. This scheme still operates but the lodged forms remain unsorted and unanalysed. However, data for the period August 1998 to July 1999 (inclusive) from 57 suburban sites were analysed and published (Grayson *et al.* 2007). This study implicated distance to the nearest bushland and housing density in explaining species richness of passerine birds.

Although a simple and consistent method for recording bird species in suburban Perth was published by Abbott (2009), it does not appear to have been widely adopted, evidenced by the lack of any recent publications. This method is an adaptation of that first used in Western Australia by D.L. Serventy (Serventy 1938, Recher 1988). It was next applied to bird surveys south of Perth (near

Rockingham, 1937–9, Sedgwick 1940), near Bilbarin in the Western Australian wheatbelt (1946, Sedgwick 1947), and near Harvey (1975–84, Sedgwick 1986). We acknowledge that there are other suburban bird survey methods available, and it is beyond the scope of this paper to review the alternatives. What we present here are the results from a survey technique that the authors found convenient to use and able to provide useful data at a local scale.

The purpose of this paper is to further illustrate the Abbott (2009) method by documenting and comparing the occurrence of bird species at two localities (in West Leederville and North Perth) during a period of four consecutive years. The places of residence are situated in Caddy Avenue (West Leederville) and Vine Street (North Perth). The two residential properties are only 1.9 km apart, and are respectively c. 3 km and 2.6 km from the GPO in the CBD, 1.8 km and 2.6 km from the nearest bushland remnant (Kings Park), and 0.4 km and 0.3 km from the nearest parkland (mostly lawn, exotic trees, relict trees, and replanted native vegetation around lakes), namely Lake Monger and Charles Veryard Reserve.

METHODS

The survey technique generates a frequency of occurrence measure for each bird species recorded, based on the number of weeks the species was seen as a proportion of the number of weeks surveyed. Details are provided in the Appendix, where it is intended to be used as a set of explicit guidelines for others who wish to adopt this method. We are confident that all common species are recorded using this method, as daily species accumulation curves show that most species are recorded within the first 3 or 4 days of each week (Table 1, Fig. 1).

Table 1. Examples of accumulation of bird species during 7 days.

Locality	Day						
	1	2	3	4	5	6	7
Caddy Ave	11	13	13	15	16	16	17
Caddy Ave	7	11	13	15	15	15	15
Vine St	8	11	14	16	17	17	–
Vine St	5	10	12	13	14	14	14

RESULTS

Species recorded

Thirty eight bird species were recorded during the period 2011–14, with 30 species at Caddy Avenue and 34 species at Vine Street (Table 2). Six of these species are introduced to metropolitan Perth, with three from outside Australia, two from eastern Australia, and one from Western Australia but outside the south-west.

Only a few species were recorded often, defined arbitrarily as those with frequency of occurrence >

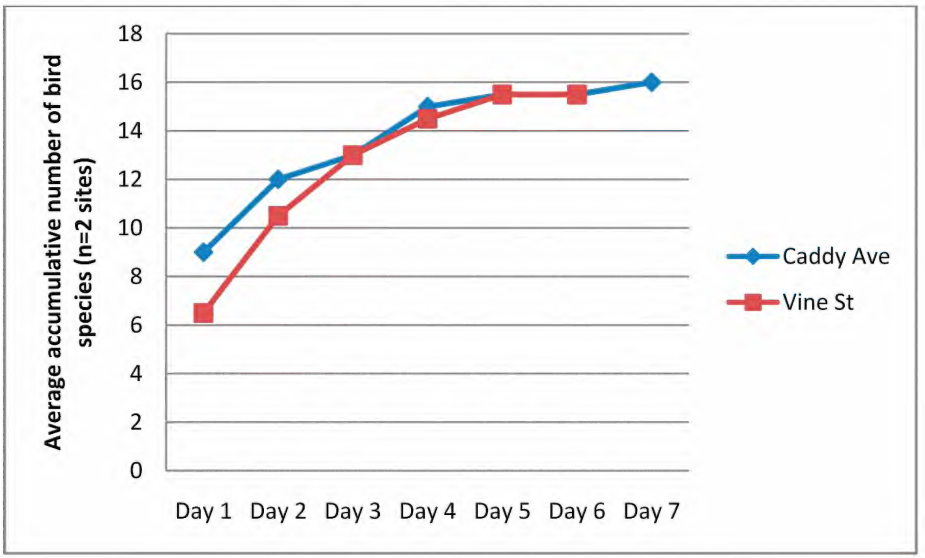

Figure 1. The cumulative number of bird species recorded at Caddy Ave and Vine St (averaged between sites, n=2) over seven days.

75% of all weeks surveyed during the 4 years of study. At Caddy Avenue, these species are the Spotted Turtle-dove (100%), Rainbow Lorikeet (100%), Red Wattlebird (100%), Singing Honeyeater (100%), Western Raven (100%), Magpie-lark (98%), White-cheeked Honeyeater (97%), Willie Wagtail (88%), Australian Magpie (87%), Grey Butcherbird (83%), Brown Honeyeater (81%), and Laughing Turtle-dove (76%). In contrast, at Vine Street the most often recorded species were the Singing Honeyeater (97%), Laughing Turtle-dove (92%), and Rainbow Lorikeet (89%).

The least recorded species (those with frequency of occurrence < 25% of all weeks surveyed during the 4 years of study) included five raptors, and one species each of a button-quail, cuckoo, owl, kingfisher, bee-eater, cockatoo, parrot, honeyeater, pardalote, and flower-pecker (Table 2).

Marked differences between Caddy Avenue and Vine Street in the frequency of occurrence of some bird species were evident. Eighteen species were recorded more often at Caddy Avenue (recorded in an average of at least 10% of surveys and at least 1.2 times more frequently, Table 2), including the Rock Dove (Domestic Pigeon, 92x more frequently), Striated Pardalote (15x), Grey Butcherbird (13x), Kookaburra (6x), Welcome Swallow (4x), Galah (2.5x),

Table 2. Frequency of occurrence of bird species recorded at, or from, Caddy Avenue (C) and Vine Street (V) in the period 2011–14[+]. Sequence and names of species follow Johnstone and Darnell (2015), except for more recent changes. * Species introduced to WA; ** Species introduced to Perth metropolitan area; *** Species presumed to be an escaped cagebird. Percentages are expressed to the nearest integer, except if < 5%.

Species	Locality	All years (%)[++]	2011	2012	2013	2014
Threskiornis moluccus Australian White Ibis	C	3.4	0	0	2	12
	V	24	25	29	25	23
Elanus caeruleus Black-shouldered Kite	C	0	0	0	0	0
	V	1	0	0	4	0
Accipiter fasciatus Brown Goshawk	C	0.5	0	2	0	0
	V	9	10	12	10	8
Haliastur sphenurus Whistling Kite	C	0	0	0	0	0
	V	1.5	2	0	2	2
Tunix varius Painted Button-quail	C	0.5	0	0	2	0
	V	0	0	0	0	0
**Columbia livia* Domestic Pigeon	C	46	100	73	10	4
	V	0.5	2	0	0	0
**Streptopelia chinensis* Spotted Turtle-dove	C	100	100	100	100	100
	V	65	58	50	58	75
**Streptopelia senegalensis* Laughing Turtle-dove	C	76	83	67	79	73
	V	92	79	94	79	100
Cacomantis pallidus Pallid Cuckoo	C	0	0	0	0	0
	V	1.5	6	0	6	0
Ninox boobook Boobook Owl	C	0.5	0	0	2	0
	V	0	0	0	0	0
**Dacelo novaeguineae* Laughing Kookaburra	C	43	60	45	29	37
	V	7	0	10	10	6
Todiramphus sanctus Sacred Kingfisher	C	0	0	0	0	0
	V	1	4	0	0	0
Merops ornatus Rainbow Bee-eater	C	0	0	0	0	0
	V	2.9	10	0	10	0
Falco longipennis Australian Hobby	C	1	2	0	2	0
	V	10	8	17	8	8
Calyptorhynchus banksii Red-tailed Black Cockatoo	C	15	12	17	0	13
	V	15	10	27	10	21
Calyptorhynchus carnabyi Carnaby's Cockatoo	C	64	69	59	58	71
	V	52	40	40	40	62
Cacatua roseicapilla Galah	C	59	50	49	60	77
	V	24	38	23	38	19
***Cacatua sanguinea* Little Corella	C	64	69	57	58	69
	V	31	38	35	38	27

******Nymphicus novaehollandiae*** Cockatiel	C	0	0	0	0	0
	V	0.5	2	0	0	0
*****Trichoglossus moluccanus*** Rainbow Lorikeet	C	100	100	100	100	100
	V	89	98	85	98	83
Platycercus zonarius Australian Ringneck	C	33	52	35	33	10
	V	0	0	0	0	0
Lichmera indistincta Brown Honeyeater	C	81	98	65	79	88
	V	44	44	42	44	38
Phylidonyris novaehollandiae New Holland Honeyeater	C	9	17	2	2	17
	V	28	31	23	31	27
Phylidonyris niger White-cheeked Honeyeater	C	97	100	100	92	90
	V	40	94	40	94	0
Anthochaera lunulata Western Little Wattlebird	C	0.5	0	2	0	2
	V	0	0	0	0	0
Anthochaera carunculata Red Wattlebird	C	100	100	100	100	100
	V	61	50	63	50	79
Gavicalis virescens Singing Honeyeater	C	100	100	100	100	100
	V	97	94	98	94	100
Pardalotus striatus Striated Pardalote	C	23	12	10	31	40
	V	1.5	2	2	0	2
Cracticus torquatus Grey Butcherbird	C	83	96	92	81	90
	V	6	2	10	2	12
Cracticus tibicen Australian Magpie	C	87	85	88	98	100
	V	47	42	50	42	52
Coracina novaehollandiae Black-faced Cuckoo-shrike	C	53	39	41	56	77
	V	43	29	50	29	33
Rhipidura leucophrys Willie Wagtail	C	88	62	96	94	100
	V	74	56	63	56	87
Grallina cyanoleuca Magpie-lark	C	98	98	100	96	96
	V	62	69	60	69	54
Corvus perplexus Western Raven	C	100	98	100	100	100
	V	46	63	40	35	42
Hirundo neoxena Welcome Swallow	C	70	92	82	67	35
	V	16	31	29	31	0
Petrochelidon nigricans Tree Martin	C	2.4	6	2	2	0
	V	41	19	48	19	50
Zosterops lateralis Grey-breasted White-eye	C	51	54	45	58	48
	V	33	48	29	48	27
Dicaeum hirundinaceum Mistletoebird	C	0	0	0	0	0
	V	4.4	6	4	2	6

\+ Percentages are based on 52, 51, 52 and 52 weeks for 2011–14 respectively for Caddy Avenue, and 52, 52, 49 and 49 weeks for 2011–14 respectively for Vine Street.

++ Calculated as (occurrence in weeks/total number of weeks) x 100% for the 4 years of the study.

Western Raven (2.2x), Little Corella (2.1x), White-cheeked Honeyeater (2.1x), Australian Magpie (1.9x), Brown Honeyeater (1.8x), Magpie-lark (1.6), Red Wattlebird (1.6x), Spotted Turtle-dove (1.5x), Grey-breasted White-eye (1.5x), Carnaby's Cockatoo (1.2x), and Willie Wagtail (1.2x) (Table 2). Species recorded more often at Vine Street comprise the Brown Goshawk (20x), Tree Martin (17x), Australian Hobby (10x), Australian White Ibis (7x), New Holland Honeyeater (3.1x), and Laughing Turtle-dove (1.2x).

Several of the least recorded species were recorded only, or more often, at one site during the period 2011–14. The Australian Ringneck, Painted Button-quail, Boobook Owl and Western Little Wattlebird were noted only at Caddy Avenue. The Black-shouldered Kite, Whistling Kite, Pallid Cuckoo, Sacred Kingfisher, Rainbow Bee-eater, Cockatiel and Mistletoebird were recorded only at Vine Street. These records are probably chance occurrences.

Changes in species recorded during the period 2011–14

At both residences most species fluctuated irregularly in frequency of occurrence from year to year (Tables 2 and 3, Figure 2a), and in some cases the annual changes were large, for example, at Caddy Avenue: Laughing Kookaburra, Red-tailed Black Cockatoo, Brown Honeyeater, and New Holland Honeyeater; Vine Street: Red-tailed Black Cockatoo, Galah, White-cheeked Honeyeater, Red Wattlebird, Tree Martin, and Grey-breasted White-eye (Table 2).

At Caddy Avenue the Domestic Pigeon declined steeply from 2013, presumably linked to cessation of the feeding of a feral population that visited from and near Oxford Street, Leederville. The Australian Ringneck, nearly all sightings of which were flyovers, declined markedly in frequency of occurrence during the 4 years of monitoring. The Galah and Striated Pardalote were recorded more often in 2013 and 2014, and the Black-faced Cuckoo-shrike occurred most frequently in 2014 (Table 2).

At Vine Street, the White-cheeked Honeyeater and Welcome Swallow were absent during 2014, suggesting that they have declined at that site (Table 2).

Averaging across both sites, the Willie Wagtail and Australian Magpie increased in frequency of occurrence during the four years of survey (Figure 3a), whereas the Welcome Swallow, Brown Honeyeater, and White-cheeked Honeyeater decreased (Figure 3b).

Seasonal changes in frequency of occurrence

Variation in the number of bird species recorded each month was similar at both Caddy Avenue and Vine Street (Table 3, Figure 2b). No seasonal pattern is

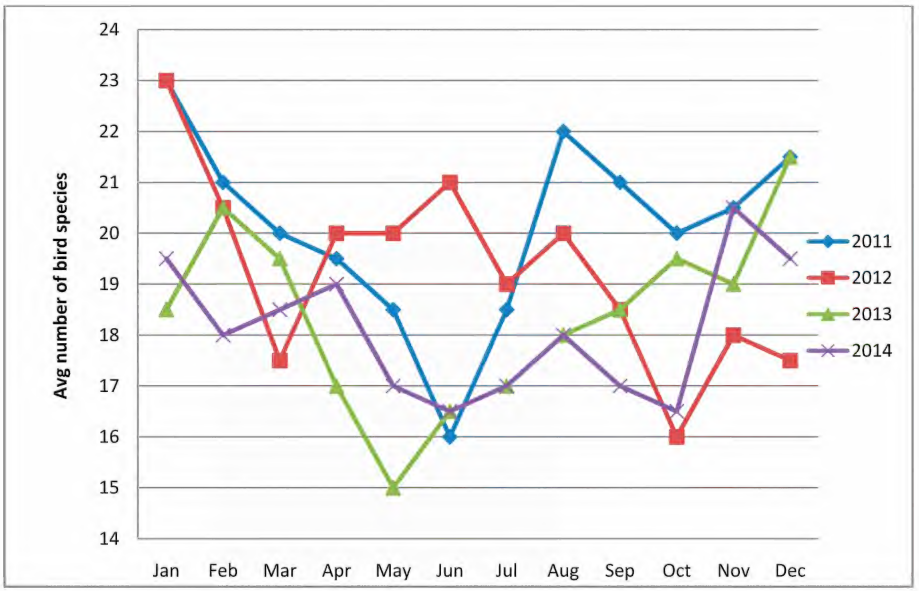

Figure 2a. Average number of bird species recorded each month for years 2011 to 2014, averaged across sites (Caddy Ave and Vine St, n=2)

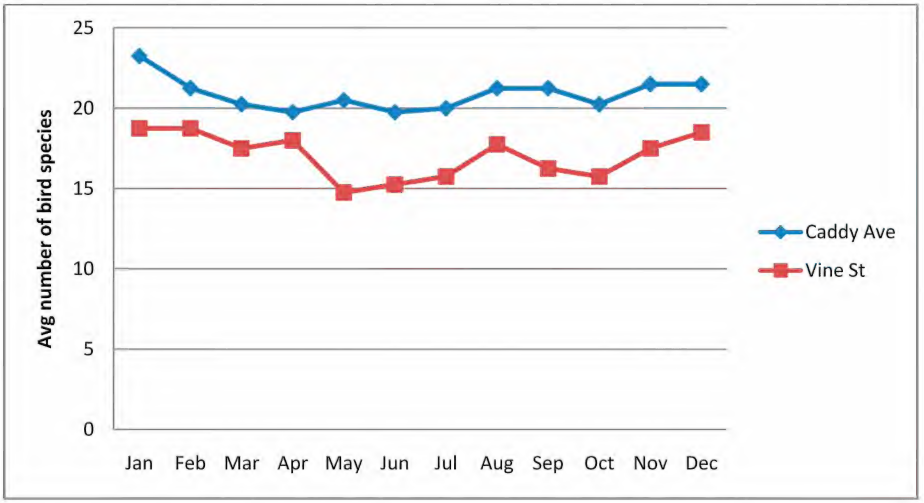

Figure 2b. Average number of bird species recorded each month at Caddy Ave and Vine St, averaged across four years (2011 to 2014, n=4)

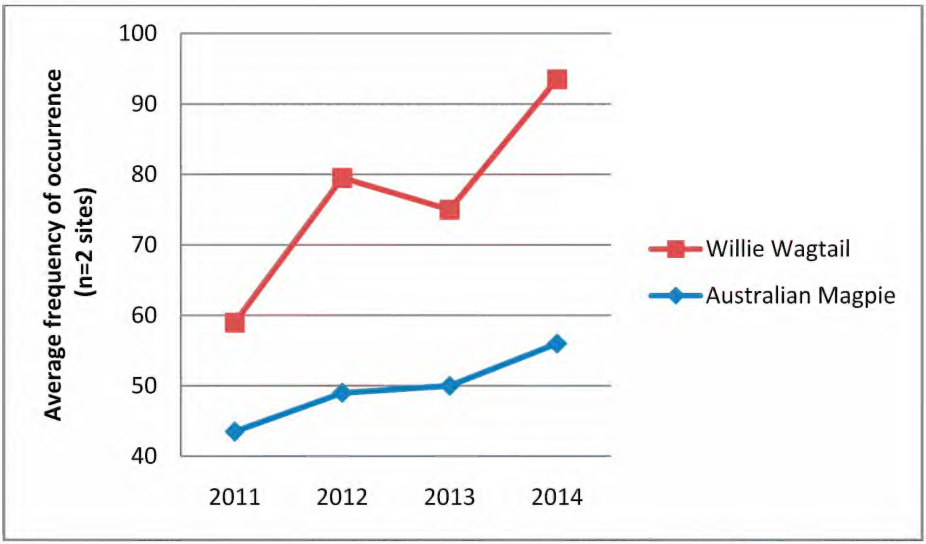

Figure 3a. Frequency of recording for Australian Magpie and Willie Wagtail, averaged across Caddy Avenue and Vine St (n=2).

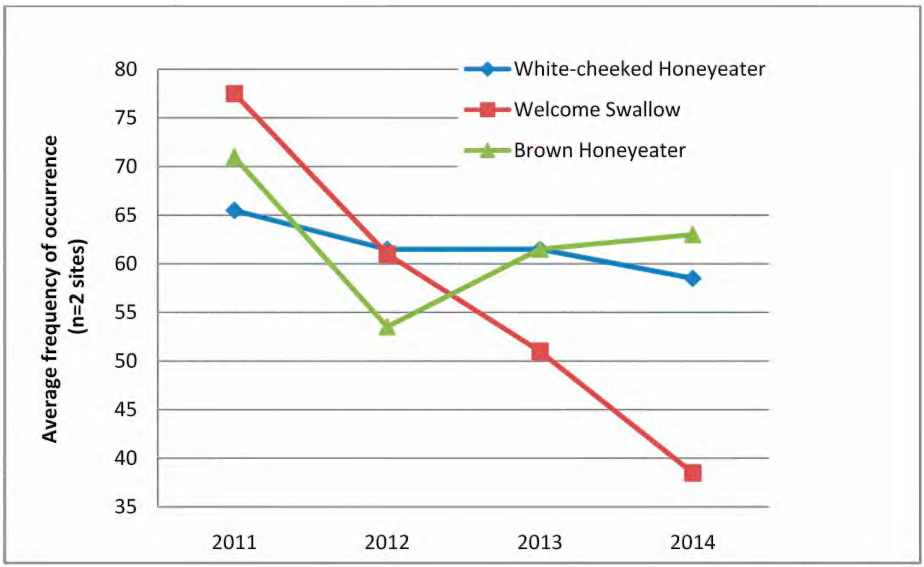

Figure 3b. Frequency of recording for Welcome Swallow, Brown Honeyeater, White-cheeked Honeyeater, averaged across Caddy Avenue and Vine St (n=2).

Table 3. The number of bird species recorded monthly at Caddy Avenue (C) and Vine Street (V) during the period 2011–14.

Year	Locality	Number of species											
		J	F	M	A	M	J	J	A	S	O	N	D
2011	C	26	23	23	21	22	20	21	25	23	21	23	22
	V	20	19	17	18	15	12	16	19	19	19	18	21
2012	C	24	22	19	19	23	20	21	22	21	17	21	21
	V	22	19	16	21	17	22	17	18	16	15	15	14
2013	C	21	20	19	18	17	20	20	18	22	23	20	22
	V	16	21	20	16	13	13	14	18	15	16	18	21
2014	C	22	20	20	21	20	19	18	20	19	20	22	21
	V	17	16	17	17	14	14	16	16	15	13	19	18

discernible (Figure 2a). Our data also indicate no obvious seasonal fluctuation for most of the species recorded at moderate (25–75%) frequency of occurrence (Table 4). The clearest changes are as follows:

Spotted Turtle-dove – Most frequent in August, October–January, Vine St

Laughing Kookaburra – Least frequent in March, April, October, Caddy Ave

Carnaby's Cockatoo – Least frequent September–December, Caddy Ave & August–February, Vine St

Galah – Most frequent August–December, Caddy Ave & November–February, Vine St

Little Corella – Most frequent November–April, Caddy Ave & November–March, Vine St

Brown Honeyeater – Most frequent January–March, Vine St

White-cheeked Honeyeater – Most frequent January–April, Vine St

Black-faced Cuckoo-shrike – Least frequent February–April, Caddy Ave & March–May, Vine St

Willie Wagtail – Least frequent May–June, Vine St

Magpie-lark – Least frequent June–July, Vine St

Grey-breasted White-eye – Least frequent July–December, Caddy Ave & June–January, Vine St.

DISCUSSION

Given the geographical proximity of the two survey sites, the similarity in age of West Leederville and North Perth (1890s onwards), and the similar density of houses typical of inner suburbs, we expected greater similarity in the bird faunas. This simple fact – that bird species show differences in frequency of

Table 4. Monthly occurrence (in weeks) at Caddy Avenue (C) and Vine Street (V) during the period 2011–14 of bird species occurring infrequently (25–75% frequency of occurrence).

Species	Locality	Number of species											
		J	F	M	A	M	J	J	A	S	O	N	D
Australian White Ibis	V	5	5	2	1	2	3	3	12	7	5	2	2
Rock Dove	C	10	8	9	8	8	5	7	8	8	9	7	7
Spotted Turtle-dove	V	13	9	9	7	7	9	8	16	7	15	18	14
Laughing Kookaburra	C	7	8	4	4	7	12	7	15	8	3	6	7
Carnaby's Cockatoo	C	10	12	15	17	15	15	11	11	6	3	8	8
	V	4	9	12	11	12	13	13	5	3	0	8	8
Galah	C	10	8	5	10	5	6	5	15	15	14	15	14
	V	7	8	3	3	1	2	1	1	1	2	13	7
Little Corella	C	16	16	16	16	3	5	2	8	8	9	19	16
	V	10	14	10	5	0	0	0	1	0	1	9	14
Australian Ringneck	C	5	6	3	9	7	7	2	4	5	6	6	7
Brown Honeyeater	V	16	12	10	18	9	6	5	6	2	0	1	6
New Holland Honeyeater	V	5	5	2	1	2	3	3	12	7	5	2	2
White-cheeked Honeyeater	V	9	12	12	9	8	7	4	5	4	4	5	2
Red Wattlebird	V	9	11	12	15	6	10	10	8	5	14	16	9
Striated Pardalote	C	6	2	0	2	3	6	3	1	4	6	10	5
Australian Magpie	V	10	9	4	14	6	8	8	14	8	8	6	1
Black-faced Cuckoo-shrike	C	7	2	3	5	10	12	8	13	11	12	17	9
	V	7	6	2	3	1	7	7	15	9	13	9	10
Willie Wagtail	V	11	12	12	15	9	9	15	16	11	14	17	14
Magpie-lark	V	10	13	10	12	8	4	4	16	14	14	13	8
Western Raven	V	10	7	7	8	6	9	5	4	10	10	11	7
Welcome Swallow	C	10	8	15	18	10	11	12	15	12	13	14	6
Tree Martin	V	7	0	5	4	5	8	4	15	7	13	9	7
Grey-breasted White-eye	C	12	16	16	19	14	16	7	4	0	0	0	1
	V	4	15	12	12	8	6	5	3	0	0	2	1

occurrence in different localities – ought to encourage others who are interested in understanding patterns of occurrence of bird species in suburban Perth to commence doing so, preferably (for the purposes of comparability) following the methods used here (Appendix).

The weekly occurrence of bird species at Caddy Avenue has been documented previously, in 1993–94, 1994–95 and 2006–07 (Abbott 2009) and 2010 (Abbott, unpublished). When these data are re-examined in relation to the records for 2011–14 presented in this paper, the differences

indicate that the suburban bird fauna is highly dynamic. For example, the Red-tailed Black Cockatoo) was widely noted in the western suburbs of Perth in early 2009 by birdwatchers (*Western Australian Bird Notes* March 2009, No. 129: 4; *The Post* [Subiaco] 1.1.2011:4; L. Christensen pers. comm. 24.1.2009). This expansion in range is seemingly correlated with poor years for marri fruiting (in 2009/10) and increased use of novel food sources such as Cape Lilac (*Melia azedarach*). This species of cockatoo was first recorded at Caddy Avenue in 2011, showing an approximate 15x increase in frequency of occurrence during the period 2011–14. Other species that showed increases were Grey Butcherbird (4x increase), Spotted Turtle-dove (2.2x), Galah (2x), Striated Pardalote (2x), White-cheeked Honeyeater (1.8x), Australian Magpie (1.4x), and Willie Wagtail (1.8x) increased in frequency of occurrence during the period 1993–2014. The Tree Martin (10x), Laughing Kookaburra (0.9x), Laughing Turtle-dove (0.8x), and Grey-breasted White-eye (0.8x) decreased in frequency of occurrence in the same period.

What are the possible mechanisms behind these temporal changes (and those observed during 2011–14 at Caddy Avenue and Vine Street) and the difference between the two sites? We consider eight potentially relevant factors.

(a) *Difference in observer competence.* Both of us have lengthy experience with the landbirds of Australia and are familiar with all of the species likely to be encountered on the Swan Coastal Plain. We consider it unlikely that any species were overlooked.

(b) *Difference in available time for making observations.* We concede that this factor is relevant, as Abbott partially retired from employment in September 2008 and thus was likely to be at home more often than Barrett, who works full time and may be absent from home on some days on assignment in the field. This may account for more of the common bird species in suburban Perth, such as the Rainbow Lorikeet, Singing Honeyeater, Red Wattlebird, and Western Raven being recorded more often at Caddy Avenue than Vine Street.

(c) *Site differences.* Differences in vegetation structure and floristic composition of gardens may be relevant, as these environmental components provide foliar invertebrates, fruit, nectar, and nest sites (Green 1984, Daniels and Kirkpatrick 2006, White *et al.* 2005).

Both sites have a few tall exotic eucalypt species visible from the place of residence. Caddy Avenue lacks street trees whereas Vine Street has a mixture of Cajuputs

(*Melaleuca*), Bottlebrush (*Callistemon*), Coastal Peppermint (*Agonis flexuosa*), and Olive trees. Lawn is very limited in extent at both sites, and verge in Vine Street mostly consists of weedy grass. Nearby gardens at both places include species such as Jacaranda, palms, cypress, Hibiscus, Frangipani (*Plumeria*), Brazilian Pepper Tree (*Schinus terebinthifolius*) and Lemon trees. Several Vine Street gardens have Rosewood (*Tipuana tipu*). The major difference between the sites is in the extent of nectariferous blossom. Several honeyeater species are highly dependent on nectar and are more likely to be present when blossom is available (particularly of *Callistemon*, *Grevillea*, *Eucalyptus* and *Melaleuca* species). In Caddy Avenue, *Grevillea* species (including the continually flowering G. *banksii* cv 'Robyn Gordon') occur in three gardens, *Eucalyptus caesia* occurs in one, and a camellia occurs in another garden, all within 100 m of 1 Caddy Avenue, whereas in Vine Street similar sources of nectar are very limited, occurring in only one garden > 100 m from 29 Vine Street. Striated Pardalotes are unlikely to occur if eucalypts (native or exotic species) are absent. Vine Street and a nearby lane have two White Cedar or Cape Lilac (*Melia azederach*) trees, an important seed source for Red-tailed Black Cockatoos in winter, whereas Caddy Avenue has one *Eucalyptus caesia* tree, also a seed source for this species.

The portions of Kimberley Street and Vincent Street West near Caddy Avenue respectively have Coral Trees (*Erythrina indica*) and Cajuputs, important winter and autumn nectar sources. Although Albert Street, near Vine Street, has Brush Box (*Lophostemon confertus*) trees, this species has little value to birds (Abbott 2009). Some gardens in this street have *Grevillea*, *Callistemon* and *E. caesia*.

(d) *Differences in proximity to parkland.* Because Council reserves near to our residences are similar in vegetation structure and floristic composition (lawn, exotic trees including eucalypts, water, restored native vegetation), we doubt that this is an important factor, except for the Striated Pardalote. This species is often recorded in Plane (*Platanus*) trees at Lake Monger reserve. Records kept regularly of landbirds at Lake Monger indicate fluctuation in occurrence of most species there (I. Abbott, unpublished observations).

(e) *Changes linked to weather.* Perth experiences a Mediterranean-type climate, with hot and effectively rainless periods in late spring, summer, and early autumn (November–April)

and cool (but not cold) and wet periods in late autumn, winter, and early spring. However, none of the bird species recorded in this study tracked this marked, effectively two season, change during each year (Table 3, Figure 2b). A shorter survey period, combined with more frequent surveys, may improve the sensitivity to seasonal variation.

(f) *Interactions between bird species.* Suburban Perth has several large bird species that prey on landbirds, particularly the Brown Goshawk, Laughing Kookaburra, Grey Butcherbird and Western Raven, as well some large species that often interact aggressively with smaller species, especially the Red Wattlebird (seen harassing fledgeling White-cheeked Honeyeaters and defending blossoming trees against visits by smaller honeyeater species) and possibly the Australian Magpie.

The most striking interspecific interactions observed were between New Holland, Singing and White-cheeked Honeyeaters. From 2006 until 2014, White-cheeked Honeyeaters were resident in Caddy Avenue and adjoining streets, and any New Holland Honeyeaters were quickly discovered by them and routed. However, in November and December 2014 and in January 2015, New Holland Honeyeaters evicted White-cheeked Honeyeaters and now remain in sole possession (at least up to March 2016). White-cheeked Honeyeaters still occur nearby in Ruislip Street. At Vine St, White-cheeked Honeyeaters were resident and breeding, but after constant fighting had, by 2013, been evicted altogether. Although Brown Honeyeaters and New Holland Honeyeaters were still recorded at Vine St in 2014, their presence in the actual garden has been reduced by the larger, aggressive Singing Honeyeaters.

(g) *Loss of habitat.* Although the landscape surrounding both locations is heavily urbanised, the loss of street and garden trees continues, as infill development for parking space and higher density accommodation removes gardens and large street trees. This is likely to be influencing the decline of species such as the Brown, New Holland and White-cheeked Honeyeaters, Welcome Swallow and Grey-breasted White-eye. The Tree Martin, a woodland bird that depends on nesting hollows, is declining in eastern Australia (e.g. Barrett *et al.* 2007), yet is still common in Perth. This may be partly explained by its use of street lamp posts and electricity power poles as nesting places (Johnstone and Storr 2004).

(h) *Normal 'ebb and flow' of populations.* Suburban Perth

has domestic cats that roam gardens at night and experiences occasional irruptions of Black Rats *Rattus rattus*. These mammalian predators presumably take their toll of birds roosting at night and of eggs and nestlings. Fluctuations in food supply linked to weather, people providing meat (as enticement or as pet food) or water, flowering of plant species, removal of trees from gardens (a consequence of 'infill'), and the use of poisons to control insect pests on garden plants are factors that could influence local populations of suburban bird species. It is also to be expected that local movements of individual birds within suburbs should influence whether a specific microgeographic site (such as a garden) will always have a particular bird species present.

Finally, we consider whether our choice of recording unit (one week) has influenced our findings. The data obtained using this method are clearly more informative than the usual composite list of bird species recorded at a site and collated over long time periods. Shorter period methods of recording (e.g. Green 1984, Barrett *et al.*, 2003, Daniels and Kirkpatrick 2006, White *et al.* 2005) should have greater sensitivity to seasonal changes but are likely to under sample species richness unless they are carried out repeatedly at the same site. We recognise that alternative methods such as the 10 minute survey of 1 ha and the 20 minute point surveys on one or more visits, can generate useful data for garden bird assemblages.

We considered monthly recording but thought it too broad, for it would take many years to accrue the same number of observations that can be assembled on a weekly basis (52 weeks/year vs 12 months/year). As acknowledged above, there are advantages to using a shorter (for example daily) survey period but this must be measured against the increased need for repeated surveys in order to ensure that the bird assemblage at any given time is properly represented. Weekly recording seemed like a reasonable compromise, providing a comprehensive list for each survey and also reducing the impact of unusual weather events such as very hot days, very windy days, very wet days or very cold days.

Our method of weekly recording was first used in 1980 (Abbott 2009). It was also devised independently and used successfully for an impressive 18-year survey of birds occurring in the gardens of Canberra (Veerman 2002).

None of the bird species observed in West Leederville and North Perth (and more generally at other sites in suburban Perth) is elusive or cryptic. However, because of their familiarity, these species may be overlooked by birdwatchers. Surprisingly little

has been recorded about the local behaviour and ecology of non-iconic, urban species such as the Singing Honeyeater (which is not present in other Australian capital cities) and the Brown Honeyeater, New Holland Honeyeater, White-cheeked Honeyeater, Red Wattlebird, Australian Magpie, Willie Wagtail, and Grey-breasted White-eye.

Previous studies of birds in Perth suburbs tend to be short-term (e.g. Davis and Wilcox 2013), use species presence/absence (e.g. Grayson *et al.* 2007), include or focus on outer suburban sites (e.g. Brooker and Brooker 1998, Grayson *et al.* 2007) or involve atypical sites (e.g. gardens immediately adjacent to bushland, Davis and Wilcox 2013), and most were conducted in the 1980s or 1990s (before the current extent of declines of some species).

The study of birds in a Perth suburban garden using methods most comparable to ours is that by Brooker and Brooker (1998). They kept weekly records at their residence in Gooseberry Hill during a 6 year period from 1984 to 1989. This garden consists of original vegetation of Marri (*Corymbia calophylla*), Wandoo (*Eucalyptus wandoo*), Parrot Bush (*Dryandra sessilis*) and heath, as well as planted eucalypts, wattles, and *Grevillea* species. This suburb is also close to the extensive forest and woodland on the Darling Scarp and Plateau. Not surprisingly they recorded more native bird species than we did, and in contrast to us observed a prolonged decrease in number of bird species from autumn to spring. The Black-faced Cuckoo-shrike was less frequent at Gooseberry Hill in winter, whereas at our sites this decline occurred earlier, from late summer to autumn (Caddy Avenue) and in autumn (Vine Street).

The frequency of occurrence of bird species in nine gardens of the inner suburb of Subiaco (Davis and Wilcox 2013) shows some similarity to our studies in West Leederville and North Perth, despite the presence of extensive bushland nearby. The species recorded were: Singing Honeyeater (100% reporting rate), Laughing Turtle-dove (93%), Brown Honeyeater (89%), Red Wattlebird (76%), Spotted Turtle-dove (69%), Grey-breasted White-eye (54%), Australian Ringneck (53%), Rainbow Lorikeet (47%), Australian Magpie (25%), Striated Pardalote (19%), Western Raven (17%), Black-faced Cuckoo-shrike (19%), and Galah, Brown Goshawk, Willie Wagtail, Mistletoebird, and Australian Hobby (all < 3%). These data relate to surveys conducted in late autumn and winter only (Davis and Wilcox 2013).

In conclusion, the method of recording the frequency of occurrence of all bird species at a fixed site for a minimum of one year is an easy way to collect useful information about urban bird assemblages. Coupled with 'bird-centric' measures of habitat structure and floristic compo-

sition, along the lines used by Green (1984), Daniels and Kirkpatrick (2006), and White *et al.* (2005), such data can provide potent information to householders, institutions, and local councils as to how to improve the suburban environment for the various native birds.

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APPENDIX

Methods used

Observations

1. A week begins on Sunday (the traditional first day of the week) and finishes on Saturday. Because most observers spend more time at their place of residence on Saturday and Sunday, we assume that less abundant species are more likely to be seen or heard on these 2 days, and hence it seems advantageous to separate these days as much as possible.
2. All bird species seen (without the use of binoculars) or heard at, or from, the place of residence are recorded, including flyovers. Binoculars may of course be used to identify species. Most birds are easily visible within 100 m of residence, but some species (such as cockatoos, parrots and butcherbirds) can be easily heard up to at least 200 m distant.
3. Waterbirds are excluded.

Record keeping

1. Prepare a table on 2 A4 sheets of paper as follows:
   (a) At the top of each page write the year and place of residence
   (b) Rule each page into rows
   (c) Rule each page into about 27 columns and label the second and subsequent columns with an abbreviated name of each bird species likely to be encountered. We order the species so that the most frequently recorded are at the left and the least frequently recorded are towards the right of the page.
2. Retain these pages as originals and keep them as blank master copies for future photocopying.
3. Make photocopies of each page as required.

4. At the start of each calendar year complete in advance the first column with the date for the Sunday closest to New Year's Day and the date of the following Saturday (Note that in some years the first recording week begins during the last week of December). Number the rows from 1 to 52, and date each row. Each row them represents a week from Sunday to the following Saturday. Keep these 2 pages in a convenient place, with a pen, so that they are readily accessible. Also provide some blank sheets of paper so that any notable observations on foraging behaviour etc can be readily recorded.
5. Weeks for which you are away from home will obviously lack records. The corresponding rows should be crossed through.
6. Record the occurrence of each species (listed in the columns) each week (identified by rows) with a tick in the appropriate cell of the table. Record each species as soon as possible after it is seen or heard. Do not reconstruct records at the end of each week.
7. At the conclusion of each calendar year, sum the occurrences and calculate the percentage frequency of occurrence of each species. For example, if a bird species is recorded as present for 5 out of 50 weeks that were surveyed, the frequency of occurrence is 10% for that year.
8. Transfer this information to a spreadsheet or table in a computer.

QUERCUS (FAGACEAE) IN WESTERN AUSTRALIA

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INTRODUCTION

The genus *Quercus*, containing over 600 species, is a Northern Hemisphere group with maximum diversity in Mexico (160 species, 109 endemic) and China with c. 100 species. Members of the genus are widely grown in temperate areas of the world. For example, *Quercus robur* L., this species or hybrid forms purportedly from Windsor Great Park, were planted as the first Honour Avenue in Kings Park, after World War 1 although only two now remain. Randall (2007) lists 129 species of oaks (including eight named hybrids) as cultivated in Australia.

Worldwide, 55 species of oaks are listed as weedy by Randall (2002): 48 as weeds (economic weeds; pests of agriculture, horticulture, turf, nurseries, etc.) and seven as naturalised. The naturalised species are: *Quercus acutissima* Carruth. (USA), *Q. canariensis* (?Aust), *Q. cerris* L. (UK, ?USA and NZ), *Q. ilex* (UK, ?Aust & NZ), *Q. robur* (USA, South Africa, Aust, NZ and China), *Q. rubra* L. (USA) and *Q. suber* (? Aust). Haysom and Murphy (2003) list four oaks as invasive; *Quercus cerris* and *Q. ilex* in the U.K., *Q. robur* invasive in S.A. and U.S.A. and *Q. actutissima* invasive in the U.S.A.

THE SITUATION IN AUSTRALIA

In Australia, treatments of the family Fagaceae, e.g. Hewson (1989) or Entwisle (1996) note that although *Quercus* species (*Q. canariensis* Willd., *Q. ilex* L., *Q. robur* and *Q. suber* L.) seed around planted trees, none were regarded as naturalised. However, more recent checklists (Walsh and Stajsic 2007) list *Quercus robur* and *Q. suber* as naturalised in Victoria.

Quercus suber has seeded in St. Kilda in Victoria along a railway line, suggesting it has some potential to naturalise (Walsh and Stajsic 2007).

Quercus robur has been sporadically recorded as escaping in N.S.W. (Cooma and Yass Valley) and A.C.T . (Council of Heads of Australasian Herbaria 2006).

Currently, *Quercus robur* and *Q. suber* are regarded as naturalised in Australia. Although listed by Randall (2002) we can find no evidence to add *Q. canariensis* or *Q. ilex* as naturalised, although given the statements by Hewson (1989) and Entwisle (1996) this may reflect a lack of documentation.

THE SITUATION IN WESTERN AUSTRALIA

At present there are no records of any naturalised *Quercus* in Western Australia (Western Australian Herbarium 1998 or Council of Heads of Australasian Herbaria 2006).

Quercus cerris (Turkey Oak), *Q. lusitanica* Lam. (Gall Oak) and *Q. robur* (English Oak) were planted in several (Big Brook, Pemberton, Donnybrook and Collie) arboreta established by the Western Australian Forests Department (Hart 1977). We have examined all these plantings and except *for Q. robur* at Pemberton (voucher: G. Keighery/B. Keighery 2203), oaks have not seeded at these sites.

However, in many old forestry settlements these and other oaks were obviously planted (although not formally documented). Many, but no means all of these scattered settlements have been visited and seeding/naturalising species recorded. At one, the old Hoffman's Mill site north-east of Harvey, we have recently recorded *Quercus palustris* Muenchh. (Pin Oak) (voucher: G. Keighery/B. Keighery 2121), established and seeding along the Harvey River.

Quercus robur, along with *Q. ilex*, is cultivated in an agricultural setting as part of successful truffle production in Manjimup and Pemberton (Department of Agriculture and Food Western Australia 2015). Additional plantings have been made in Toodyay, Margaret River, Walpole, and Denmark for this purpose (Department of Agriculture and Food Western Australia 2015). *Quercus robur* has also been planted in horticultural settings throughout the southwest from Albany to New Norcia with notably large individuals in Bridgetown (McIntosh n.d.) and Donnybrook (Smith 2009). The tree in Donnybrook was formerly recognised as Australia's largest oak tree (Smith 2009) and is believed to have been planted around 1890. Several apparently naturalised individuals including one large recently dead tree were noted along the Mundaring Loop trail and the adjacent Goldfields Water Supply Scheme pipeline (M. Lohr s.n., 21/6/2015, PERTH). These trees appear to have spread from two large mature horticultural specimens of *Quercus robur* found approximately 200m away in a grassy picnic area of Frederic Jacoby Forest Park. The larger of these two trees is heritage listed and was planted around 1870 (Heritage Council of Western Australia 2016). The presence of the naturalised trees on the opposite side of a gully from

their apparent source suggests movement of acorns by animals.

Quercus suber (Cork Oak) is occasionally grown as an ornamental tree on private land in south-western Western Australia. This species is native to the western Mediterranean basin, an area with similar climate to south-western Western Australia. We have observed ostensibly healthy specimens of this species persisting without supplementary water in Kellerberrin. Mature trees have a thick bark which is used commercially in cork production in its native range and allows large individuals to survive crown fires (Pausas 1997). It is also unique among European trees in its ability to regenerate after fires via epicormic branching (Moreira *et al.* 2007). We observed approximately twenty mature flowering Cork Oaks in a small grove along the edge of Ashton Road north of the town of Margaret River (M. Lohr s.n. 7/11/ 2015, PERTH). The largest of these trees were roughly evenly spaced and appear to have been planted intentionally. These trees reached the mid-storey of a mixed pine and eucalypt forest and may have been planted in association with historic operations at the nearby Wharncliffe Saw Mill. Seedlings and saplings were present up to a distance of about 20m from the mature trees.

DISCUSSION

Three species of oaks (*Q. palustris*, *Q. robur* and *Q. suber*) have established naturalised populations in Western Australia.

Oaks, despite the large numbers of species cultivated and several seeding abundantly, have been poor colonisers in Australia. In Western Australia, they are probably disadvantaged by our very poor soils and unlikely to naturalize in most situations. Lack of suitable mycorrhizae, summer droughts, and fire contribute to preventing the establishment of mature trees in most oak species. However, large-scale cultivation of *Q. robur* and *Q. ilex* in suitable habitats coupled with the commercial availability of saplings inoculated with truffle mycorrhyzae may diminish some of these barriers to naturalisation in areas with high rainfall. Vigilance is recommended in areas of bushland bordering commercial cultivation. Of the oak species currently present in Western Australia, *Q. suber* is best adapted to a Mediterranean climate, most tolerant of fires, and the only species with potential to naturalise outside the wettest areas of the State.

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PROTEA REPENS (L.) L. (PROTEACEAE), A NEW NATURALISED RECORD FOR AUSTRALIA

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ABSTRACT

Protea repens is recorded as locally naturalised in the Perth Hills. This appears to be the first substantiated record of a *Protea* species naturalising in Australia.

INTRODUCTION

The Proteaceae are a medium sized family of c. 1600 species of shrubs and trees, largely from the southern hemisphere, with over 80% of species from Australia and South Africa. The African genus *Protea* comprises c. 100 species with the great majority from South Africa (Mabberley 2002).

NATURALISED PROTEACEAE

Moodley (2013) recorded 58 species of Proteaceae naturalised worldwide, with 8 (*Banksia ericifolia, B. integrifolia, Grevillea banksii, G. robusta, Hakea drupacea, H. gibbosa, H. salicifolia* and *H. sericea*) being invasive. The majority of these are invasive weeds in southern Africa. Currently there are 13 species of Proteaceae with naturalised populations in Western Australia (Table 1) of which five have at least to some degree, invaded natural bushland. Richardson *et al.* (2011) list 13 species of Proteaceae from the genera *Grevillea* and *Hakea* naturalised in Eastern Australia. Currently all naturalised species of Proteaceae recorded in Australia are Australian natives.

This is a low number of members of a moderate sized family to have naturalised, however, as Moodley *et al.* (2013) note; few members of the family have been widely introduced or cultivated. This is changing as many Proteaceae are now cultivated or have been trialled as cut flowers, which is the cause of recent naturalization of several *Banksia* species in South Africa.

Table 1. Proteaceae with naturalised populations in Western Australia

Banksia canei naturalised on road verges near Porongurups.
Banksia hookeriana naturalised and invading bushland at Trigg Dunes Reserve.
Banksia integrifolia naturalised along drain at Hamel.
Banksia victoriae naturalised and occurring in bushland at Hartfield Park.
Banksia undata subsp. *undata* naturalised in very disturbed bushland at Shenton Park
Grevillea leucopteris naturalised and invasive in Bushland at Hartfield Park.
Grevillea olivacea naturalising from plantings at Woodman's Point.
Grevillea rosieri naturalised along roadside at Burekup.
Hakea costata, naturalised and invasive into bushland at Kings Park.
Hakea laurina naturalised in disturbed bushland at Waroona, and on roadsides in the Perth hills. Also weedy in South Australia.
Hakea dactyloides naturalised in the abandoned Forestry Department arboretum at Donnybrook.
Hakea drupacea naturalised on a road verge at Yarloop. Also weedy in Victoria and South Australia.
Hakea pycnoneura naturalised and established in bushland at Kings Park.

PROTEA IN AUSTRALIA/ WESTERN AUSTRALIA

Moodley (2013) in her world wide review was not able to locate any records of any member of the genus *Protea* recorded as a naturalised species. However, Randall (2007) lists 68 species and hybrids of *Protea* as cultivated in Australia, of which two species are recorded as naturalised. *Protea repens* (under the old name *P. mellifera*) is listed as naturalised for Australia based on Mulvaney (1991) and *P. subvestita* is listed as naturalised in New Zealand. We were unable to locate any collections in Australian Herbaria (AVH, 2016) or other information to confirm the first record. Howell and Sawyer (2006) list *Protea subvestita* only as a casual alien for New Zealand, but not naturalised.

Protea repens is the most widespread and variable of the southern African Proteas, occurring throughout the south-western, southern and eastern cape, normally in lowland areas below 600 metres (Rourke 1980). It was one of the first Proteas cultivated flowering in England by 1780 and growing in Australia, New Zealand and California as a garden plant and for cut flowers by 1890.

The species grows best in the Perth Hills and areas south of Bunbury. The form that has naturalised in Western Australia appears to be the "Western Cape

Variant" (Rourke 1980) which has either pure white or white bracts tipped red and is autumn flowering (April to May, Figure 1) compared to the red bracted, summer flowering upland form. There are two roadside populations of *Protea repens* in the

Figure 1. Inflorescence of *Protea repens*, flowering at Mundaring in May, showing the red tipped bracts of the South Western Cape form (Photo: G. Keighery).

Perth hills at Mundaring and Pickering Brook. In both locations many hundreds of plants are established along the road verge and in adjacent disturbed bushland. The populations consist of plants ranging from small seedlings to large mature adults up to 3 metres tall. Both populations are readily visited by local honeyeaters and set a large number of seed filled inflorescences. Although these are retained on the plant, normally until the plants are killed by fire, it appears in both populations that drought death, roadside pruning (both intentional and by vehicles), branch death and occasional small scale fires releases a substantial amount of seed.

It is of interest that, approximately midway between the two localities reported here, a single plant of *Protea repens* was present on a property with no known method of origin in the 1950's (John Dell, pers. com). This plant persisted for about 10 years before dying, perhaps a victim of *Phytophthora* which was becoming rampant at the time.

Currently the voucher collection from Pickering Brook in Western Australia is listed as introduced and naturalised on Florabase (Western Australian Herbarium 1998–). We consider that these records are the first substantiated documentation of a naturalised *Protea* in Australia.

In Australia members of the genera *Banksia*, *Leucospermum*, *Protea* and *Serruria* are widely cultivated for cut flowers, mostly propagated from seed (Matthews and Carter 1993). However, recently the trend has been to use hybrids or horticultural selections propagated vegetatively for consistency, so it is possible that few members of the family will enter our weed flora by this route in the future. Although species could be still establishing feral populations and entering via this route at present. It is more likely they will be introduced via amenity plantings or road verge plantings as has occurred in a series of *Banksia* species (Keighery and Keighery 2015) and for all of the species in Table 1.

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STATUS OF *PASPALUM DISTICHUM* L. AND *P. VAGINATUM* SW. (POACEAE) IN WESTERN AUSTRALIA

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ABSTRACT

In Western Australia, *Paspalum vaginatum* and *P. distichum* should be regarded as native components of the springs and permanent wetlands of the Kimberley and adjacent arid areas, but introduced into southern Western Australia. *Paspalum distichum* and *P. vaginatum* should be listed as native and naturalised in Western Australia.

INTRODUCTION

There is considerable confusion about the native or naturalised status of many widespread naturally weedy tropical species in Northern Australia. This confusion applies to both fresh water (*Paspalum distichum*) and salt water couch (*P. vaginatum*) in Australia, and especially in Western Australia.

This note was prompted by a request for clarification about the weedy significance of *Paspalum vaginatum* from the managers of the Eighty Mile Beach/ Mandora Marsh Ramsar wetland who were planning weed control of significant weeds in the wetland and surrounds. One species prioritised for control actions was the grass *Paspalum vaginatum*, which is listed as a naturalised species for Western Australia in Florabase (Western Australian Herbarium 1998–).

HISTORICAL INFORMATION

Bentham (1867) listed both species as native under *Paspalum distichum*, but Webster (1987) in his revision, listed both species as introduced to Australia.

Jacobs and Wall (1993) list both species as native for New South Wales. Bostock and Holland (2007) list both species as native to Queensland. Dunlop *et al.* (1995) for the Northern Territory lists the only species present, *Paspalum vaginatum* as native.

Jessop (1986) gives *P. vaginatum* as

native and *P. distichum* as naturalised for South Australia. However, in a later review, Jessop *et al.* (2006) list both species as naturalised and note that in a very intensively collected State, the first South Australian record for the genus was in 1940. Walsh (1994) gives both species as naturalised for Victoria, and notes the relatively recent and few herbarium records of *P. vaginatum* (in 1937, 1970, 1987 & 1990) for that State. Only *P. distichum* has been recorded in Tasmania and this species is regarded as naturalised.

Paspalum vaginatum was collected by Banks in Queensland in 1770 and by Brown at Port Jackson, New South Wales in 1802. Brown's collection forming the type of *P. littorale* R.Br., named only 15 years after *P. vaginatum* was described from material collected in Jamaica. Brown also collected *Paspalum distichum* on Goods Island in the Torres Straight in 1802. This suggests a long Pre-European history in Australia for both species in the tropics and sub-tropics.

Currently, the Australian Plant Census (Council of Heads of Australian Herbaria, 2006–) lists *P. vaginatum* as naturalised in Western Australia and Victoria, with native and naturalised populations in the Northern Territory and native in Queensland and New South Wales. *Paspalum distichum* is listed as naturalised in Western Australia, South Australia, Australian Capital Territory and Tasmania, native in Queensland and New South Wales and of uncertain status in Victoria (populations may be native or naturalised).

STATUS IN WESTERN AUSTRALIA

Gardner (1930) and Green (1985) list both species as naturalised in Western Australia. In the Flora of Perth Region Bennett (1987) notes that both species are native to the tropics but introduced into southern Western Australia. However, Oldfield collected *P. vaginatum* at the Murchison River in 1859, suggesting that the species may have been native to at least parts of southern Western Australia. Neither species were covered in the Flora of the Kimberley (Wheeler *et al.* 1992).

The earliest collection of *Paspalum distichum* was from the Vasse River in 1898. Nearly all collections of *P. distichum* from southern Western Australia are from weedy or altered wetlands. However, in the Kimberley the status of *Paspalum distichum* is harder to establish. The species is known from collections from Wanganut Spring on Dampier Peninsula in 1984, March Fly Glen on the Derby-Gibb River road in 1982 and a cultivated collection from a paddock at Ivanhoe Crossing, Kununurra in 2002.

Paspalum vaginatum is also rarely recorded in the Kimberley being only collected at a few mound

springs (Brolga Springs) and along the lower Ord River, both post 1998. It is also rare in the adjacent desert being only known from several mound springs: Dragon Tree Soak in 1977 and Fern Springs in the Mandora Marsh in 1999.

Such late collections may indicate a non-native, or alternatively a species naturally confined to rare permanently wet habitats (Mound Springs of the Kimberley are a listed threatened community in Western Australia). This certainly appears the case for *Paspalum vaginatum* and I am more inclined to this viewpoint. Certainly the species does not behave as a recently introduced spreading weed. The collections from the Kimberley of *P. distichum* suggest the species could be regarded as native and introduced.

CONCLUSION

Paspalum vaginatum and *P. distichum* should be regarded as a native component of the springs of the Kimberley and adjacent arid.

In the case of *Paspalum vaginatum*, Western Australia should largely follow the Australian Plant Census (Council of Heads of Australian Herbaria, 2006–). In the tropics and subtropics, Queensland, New South Wales and the Northern Territory *Paspalum vaginatum* is native (no mention of naturalised populations were noted in the Northern Territory listings). The temperate states Victoria, South Australia and Western Australia list the species as naturalised. This seems reasonable except that for the Kimberley and adjacent tropical arid of Western Australia, where *Paspalum vaginatum* should be regarded as native; hence Western Australia has both native and naturalised populations. It is possible that some riverine populations in the Geraldton area may be native and require further study.

Paspalum distichum should be given as native to Queensland and New South Wales, naturalised in South Australia and Tasmania, native and naturalised in Victoria and Western Australia.

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OBITUARY

BETTY DOREEN WELLINGTON (*NEE* TURNER)

1921–2015

Betty Wellington was born in Fyfield, Berkshire, England on 9 October 1921 and died at Northam Hospital, Western Australia on 20 December 2015 aged 94 years.

Betty married Henry Frederick George Wellington on 6 July 1945 and had two children, David who lives in Manjimup, Western Australia and Sandra who lives in England. Following her husband's death after a long illness, Betty visited Australia in December 1972 before deciding to emigrate to Perth in August 1974. She became an Australian citizen in January 1982.

Betty joined the Naturalists' Club in 1977 when I was President. She was elected to the Club Council in 1980 and served as Secretary in 1984 and 1985 and Vice-President in 1991 to 1992. She edited the Club's newsletter the "Naturalist News" in 1982.

Betty had a great love for animals and was an avid reader which made her very knowledgeable especially on Australian reptiles. She volunteered to help Ric How and me at the WA Museum to do whatever needed to be done especially if it involved working with reptiles. This timing was impeccable as it corresponded with the time when major fauna surveys were being conducted in remote parts of Western Australia. Betty became pivotal in our laboratory at a time before computer data-basing became commonplace. Betty was meticulous in filling out a single data page for each specimen including all external measurements together with information that she gained by dissecting each

Betty as a volunteer on the Hotham Valley Railway.

Betty with son David at her Australian Citizenship ceremony in January 1982.

specimen to determine what it fed on as well as detailed notes on reproduction. This work by her resulted in Betty becoming a co-author with Ric and me on some significant papers in international journals. One such paper: How, R.A., Dell, J. and Wellington, B.D. 1986. Comparative Biology of Eight Species of *Diplodactylus* Gecko in Western Australia. *Herpetologica* 42: 471–482 was particularly significant to her as it included information on specimens of what had not then been recognized as a new species. Two years later in 1988 this was named by Glen Storr as *Diplodactylus wellingtonae* in her honour. With later changes in generic understanding it became *Strophurus wellingtonae.*

Another paper that resulted from Betty's prodigious laboratory work is: How, R.A., Dell, J. and Wellington, B.D. 1990. Reproductive and Dietary Biology of *Nephrurus* and *Underwoodisaurus* (Gekkonidae) in Western Australia. *Records of the Western Australian Museum* 14: 449–459.

Betty's voluntary work with the Museum was not all laboratory based. Ric and I were able to

include her on a number of surveys in the Eastern Goldfields. These surveys, which were each about three weeks duration, included the Woodline area east of Norseman, Buningonia Spring south of Zanthus, Yuinmery Station, Banjawarn Station, Mount Jackson, Helena and Aurora Range, Lake Cronin and McDermid Rock. On one of these surveys we were able to celebrate Betty's 60th birthday. This took a bit of planning and subterfuge so that it would be a surprise. We had stored the cake in the gun cupboard in the caravan because we knew that Betty would never open this cabinet. On the day of her birthday nothing was said and by mid-afternoon it was obvious from her demeanour that she thought we had forgotten. We managed to get Toni to lead her away from the camp on the pretext of showing her a Boobook Owl in a hollow log. This was difficult as she knew that owls didn't live in logs but she thought she had better humour him anyway. By the time she arrived back at the camp I had managed to make the icing but it kept sliding off the cake because of the heat. Anyway the candles were greatly appreciated and the cake was described as delicious.

In 1984 the Naturalists Club in partnership with the WA Museum began a two-year survey of the mammals, reptiles and amphibians of a section of the Darling Scarp near Lesmurdie. Betty undertook most of the reptile survey with a great deal of assistance from two of the Club's younger members, Brad Maryan and David Robinson. The results of this survey were published as: Wellington, B.D. and Dell, J. 1989. Reptiles and Amphibians of the Darling Scarp near Perth. *Western Australian Naturalist* 17: 226–228.

Betty loved everything about Australia as her voluntary service attests. Apart from her work at the Museum and for the Naturalists' Club, she was an avid volunteer at June Butcher's Kanyana Sanctuary spending many hundreds of hours helping to look after all sorts of injured or orphan animals. She also liked steam trains and was a long-term volunteer on the Hotham Valley Tourist trains that took people from Perth to Toodyay or to Dwellingup or to Wannamal depending on the season.

When Betty arrived in Perth she lived in Gooseberry Hill which was so convenient to many of her volunteer projects. When a shortage of money meant that she would have to dispose of her trusted little Bongo Van, she found another solution. Land prices were much cheaper further from the metropolitan area, so she sold up and moved to Mt Helena. After a number of years there, she was obliged to move further out and found a place in the little township of Wundowie. Here she was also very happy and again took up new interests and voluntary work with the local community as mentioned in the tributes

Celebrating Eric McCrum's 70th birthday May 2004. L-R: Betty Wellington, Joy Dell, Eddie Dell, David Garlick, Sylvia Garlick.

presented by Club members at her funeral at Pinaroo Memorial Park. The first was by **Eric McCrum:**

"What an amazing lady! Few would know her hidden talents. We, in the Darling Range Branch of the WA Naturalists' Club, were so fortunate to have her as one of our earliest members. When Kevn Griffiths and I dreamt up starting a branch of the Nats Club up here in the hills in 1974, only 4 years later, in 1978, Betty became a committee member. She then became Chairman of our branch in 1979 and 1980, a committee member in 1981, and secretary in 1982. Two years later, she was assistant vice-chairman, and again secretary in 1986. After 8 years in various official positions of our branch, Betty decided to continue her interests by volunteer work at the Perth Museum.

In 1980, while the DRB was invited to do a nature survey at Lake Leschenaultia, Betty undertook to survey the "lizards" of the area. This, and her volunteer work at the Perth Museum, working on reptiles, eventually led to the naming of a new gecko in her honour, Strophurus wellingtonae, the Murchison Spiny-tailed Gecko.

Betty gave a number of presentations to the branch including: July 1982 Mammals of WA; November 1982 Reptiles – hot or cold; July 1986 Remarkable Australian Reptiles; February 1989 Geckoes; March 1994 Survival: Dinosaurs to Geckoes.

In 1985, Betty organised the "Endangered Species" report at the Wildlife Rehabilitation Conference at Murdoch University. Later in October 1986, she was involved with the DRB exhibit at the Wildlife Show in Kalamunda, and in June 1990, with the reptile exhibit at the Wildlife Show at Herdsman Lake.

Betty attended over 100 meetings with the DRB, and over 50 camp-outs with our branch. Betty, it was an honour to know you."

Another tribute was by **Kevn Griffiths**:

"Betty was certainly an amazing person and her contributions to the DRB of the Naturalists Club were greatly valued. To expand a little on the Lake Leschenaultia surveys being carried out by the DRB, mentioned by Eric, Betty, with the knowledgable people all around her with the likes of those knowing the names of wildflowers, the names of the birds of the area, and even the fish in the lake, said to me that she would like to specialise in something in natural history. I said, "what about lizards" and that I'd be happy to go along with the idea as I could identify a Bobtail lizard and that was about it! And away she went and in no time Betty became our expert on lizards and other reptiles at our DRB meetings and also a volunteer at the WA Museum doing the likes of dissecting lizards to see what they ate! Her reward as Eric has said was the naming of a gecko after her.

Another latent talent of Betty came to light in September 1999 when Eric and I ran a joint natural history come art course at the Eyre Bird Observatory which is on the coast below Cocklebiddy. Eric covered the natural history side of the area in the morning and I the sketching side of the outdoors working mainly in pencil with shading. After lunch, the artists would go and chase bugs with Eric and Eric's morning group would draw them with me.

Betty soon excelled with her black and white work and as a result when we got back home felt she needed to further what she had learnt at EBO and so our little mini art club was born. Betty of course focussed much of her work on lizards on driftwood and the like, now adding a touch of colour to further enhance her pictures, now full paintings. She then moved to Wundowie and joined the local art group and extended her skills to mosaic tiling at which she, again, excelled. This is just another example of the remarkable, enthusiastic drive whether camping in her little Mazda Bongo or not, that Betty as a now, certified Aussie, exhibited in her adopted country, She lived life to the full and really loved it. A truly remarkable lady."

JOHN DELL

FROM FIELD AND STUDY

Actions of Button-quail in response to fire – The activity of a covey of eight Chestnutbacked Buttonquail *Turnix castanota* when caught in front of an encroaching bushfire is worthy of note. In September 1990 I was one of a party of ornithologists leaving the area of Merten's Falls in the Kimberley, Western Australia. The high daytime temperatures encountered were normal for the region. On a nearby ridge we encountered a rapidly approaching low intensity bushfire. Fanned by a north-easterly wind of varying strength, the flames moved with the breeze along the ridgeline. Vegetation in the area was a mix of open eucalypt savannah woodland interspersed with palms. Flames were at times approaching heights of three metres and were producing a steady roaring sound. The fire line was rapidly consuming all combustible material in its path removing, from the smoke filled eucalypt and palm growth, the understorey of dry grass, leaf litter, dry bark, leaves and palm fronds to a height of about five metres.

With the advent of a bushfire the activities of wildlife may be anticipated with little difficulty. Avian species such as passerines simply remove themselves from danger whereas raptors find the effects of fire beneficial for feeding, circling above or moving in front of the flames to capture those unfortunate animals exposed or pushed from the safety of cover. In the northern tropics how often does an observer witness Black Kites *Milvus migrans* and Whistling Kites *Haliastur sphenurus* flying through the smoke of a grass fire or Brown Falcons *Falco berigora* pouncing immediately in front of encroaching flames? What then do other birds do to try to evade such potential life threatening flames? Birds that opt for flight as an escape mechanism simply fly away or as has been occasionally shown succumb to the subsequent inferno, their incinerated remains being found still clinging to a burnt branch or lying on the scorched earth. At waterside locations bodies can be found lying at the water's edge.

At a slight curve in the dusty track, and after the first vehicle had driven by, a covey of Chestnutbacked Buttonquail began appearing at the track edge some 20 metres in front of the flames. Their actions indicated that they were aware of the potential danger from the approaching flames. The occupants of our leading vehicle had not seen them and it appears that they had arrived at the site just ahead of me. They proceeded to leave the grass and leaf verge and move onto the dirt track in an apparent attempt to evade the encroaching flames, none appearing to attempt crossing the track. The track was a single vehicle one and had a surface of fine dust and loose sand with a

scattering of broken sandstone pebbles and devoid of ground litter. The first four birds to enter the relative safety of the track assumed a somewhat flattened pose, and with a series of kicks and wing flicks were constructing shallow depressions similar to the scrapes or 'platelets' commonly produced by buttonquail.

They gained a coating of fine dust over their entire body surface. The remainder of the covey, still within the fire threatened vegetation, being disturbed by our presence, refused to leave their cover and melted back into the bush. The first four remained ensconced in the dust of the track and showed little fear; in fact allowing a close approach towards their suspected safe position. At this point the approaching fire front was within five or six metres of both the track and the birds. Considering the safety of the birds remaining in the vegetation as well as those on the road (and me) I considered it unsafe for the observations to continue and reluctantly departed. It remains unknown as to how the remaining birds, who had returned into the bush, had handled the situation. Allowing for the wind and low intensity of the flames I would assume that the four birds, should they have remained in their scrapes, could have safely evaded the fire as it would have passed quickly.

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CLUB NEWS

Programme

General Meetings and Branch Meetings are held at various venues in Nedlands, Kalamunda, Rockingham and North Beach.
The Retired and Leisured Group meets on alternate Wednesdays at 10a.m.
Excursions and field days are planned from time to time and will be advertised in the Club's monthly newsletter "The Naturalist News".

THE WESTERN AUSTRALIAN NATURALIST
(Journal of the W.A. Naturalists' Club)

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Members are reminded that they may make financial contributions to the club. This funding is very important from the Club's point of view, as it helps our publication activities, field station maintenance and other miscellaneous activities. Members are asked to remember the club and its needs when preparing their Wills and Testaments.
The WA Naturalists' Fund is entered in the register of Environmental Organisations. Donations of $2.00 and over are tax deductible under item 1 Section 30-15 and Subsection 30B of the Income Tax Assessment Act 1997.

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